AUG 6 1942

Heating Piping & Air Conditioning

DESIGN
INSTALLATION
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MAINTENANCE

AUGUST ★ 1942

INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

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Open Book on WARTIME CARE OF V-Belts

Texrope Super-7's new Design-Against-Wear points to ways *You* can make V-Belts last longer — whatever brand you now use — saving equipment vital to Victory Production!

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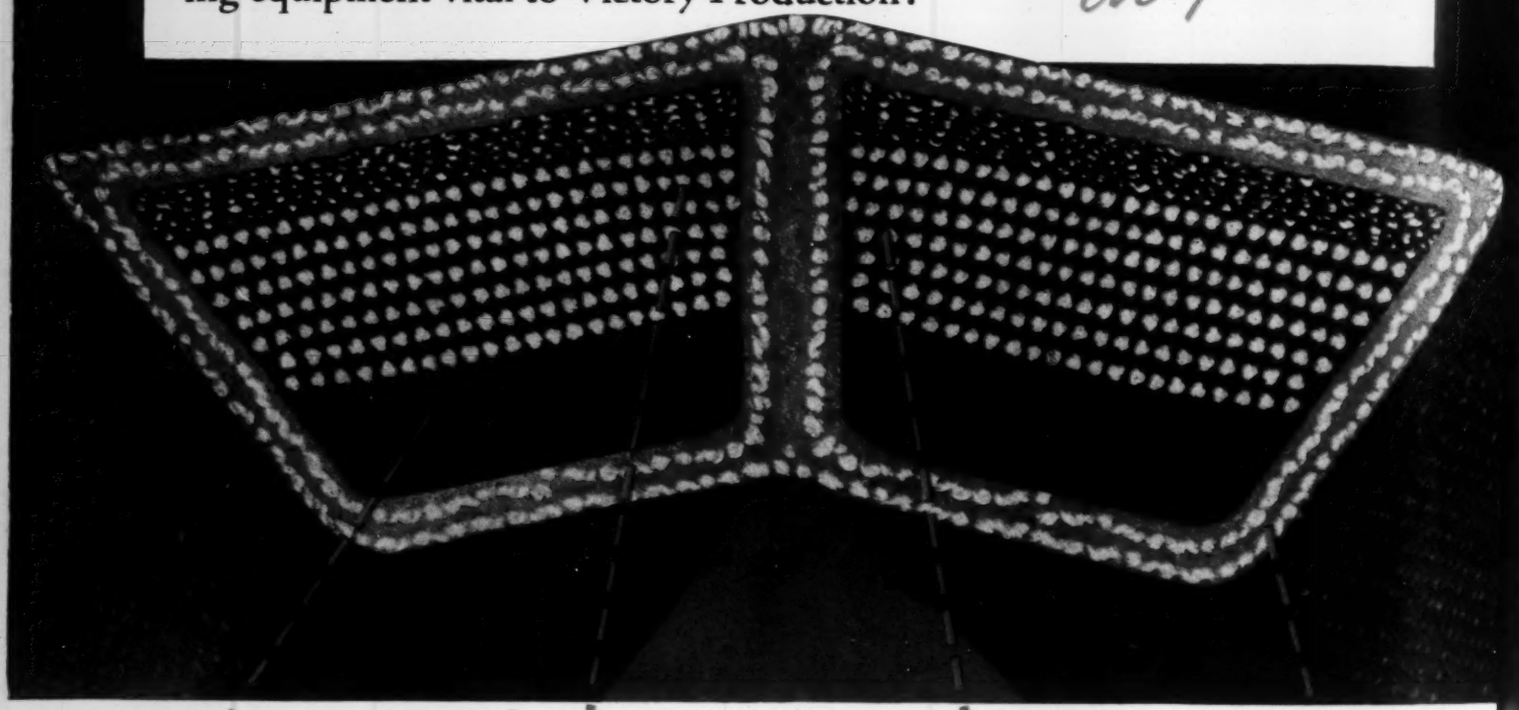

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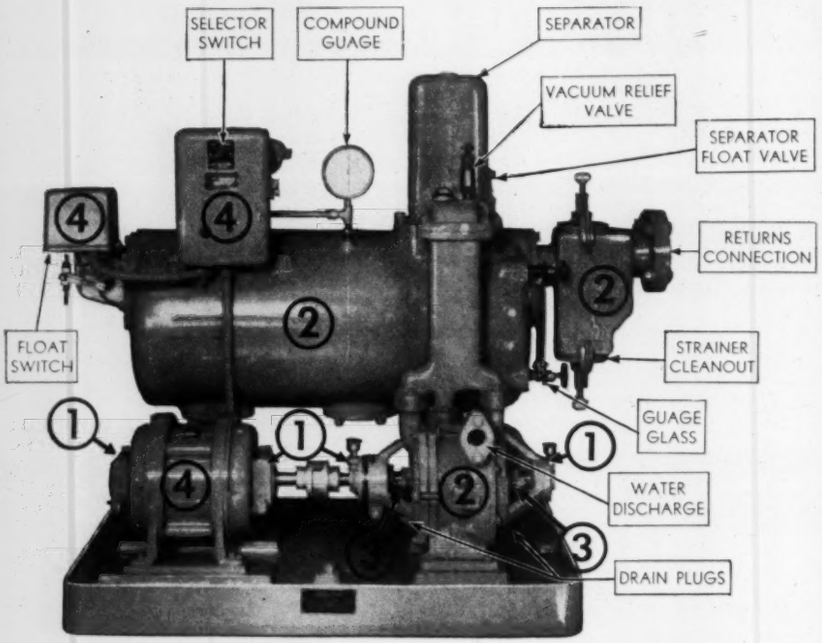
How to keep your Jennings Heating Pumps in First Class operating condition for Duration . . .



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are an important part of plant or building equipment. They cannot be easily replaced and must last for a long time. Jennings Pumps are designed for long life, and have extra capacity which will count when it may be difficult to maintain lines and equipment free from leaks, but to give full service they must have proper care.

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3 RENEW STUFFING BOX PACKING . . . Remove old packing and clean stuffing box. Fill with new loose-woven graphite-impregnated stuffing box packing, in individual rings. Be sure joints are staggered, and that ends butt properly without over-lapping. Do not finally tighten gland until pump is again in operation.

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6 IF PUMPS REQUIRE REPAIRS . . . and you do not know the address of our nearest Service Branch, notify us at once, and we will have our Service Engineer get in touch with you without delay . . . There are well equipped Nash Service Branches in most principal cities, ready to give you every possible help.

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Your Place in the "SMART MAN'S WAR"

WARFARE, 1942 style, requires such enormous quantities of material that many of our production problems now hinge on the question of the *most judicious* use of our remaining resources.

Emphasis to this statement is given in a recent book, Your Business Goes To War. In it, the author points out that the quantity of material used in war can be traced through the rather gruesome index of "the cost of killing a soldier." From $0.75 in Caesar's War, the cost rose to about $50 in the Thirty Years' War; from $5000 in the Civil War, the figure rose to $25,000 in World War I.

Recent estimates indicate that $125,000 represents the cost of killing an enemy soldier now. Certainly these figures give an indication as to the vast quantities of material which must be pulled into this conflict. They indicate that each of us must look the situation over and see what he can do to utilize most effectively our storehouse of materials and manpower. As Donald Nelson recently said, "This is neither an old man's war, nor a young man's war. It's a *smart* man's war. Our enemies have made it so."

Unfortunately, the field of conservation effort is frequently regarded as being largely limited to gathering of scrap. The overall conservation effort, which is much broader than that in its scope, and which was well established in World War I, can be summed up under four general headings:

1) *Substitution*—This is one of the most obvious measures and involves the practice of using the least critical material in each object where short term performance is not too adversely affected by the substitute itself.

2) *Salvage*—This measure, which is as readily apparent as substitution, involves the rounding up of all material of the type in which a critical shortage exists.

3) *Simplification*—The reduction of product types and sizes made possible by simplified practice results in elimination of short run production schedules; less frequent time consuming machine setups; release of valuable equipment, and/or floor space; reduction of handling and transportation—thereby permitting substantial increases in manufacture of the essential types and sizes, and making available manufacturing facilities for "bottleneck" equipment.

4) *Specification*—This is probably the least obvious phase of conservation activities, and falls under two general headings:

a) The armed services have become the largest purchasers for all industries and since the services buy almost entirely on specifications and since manufacturers are continually substituting and simplifying their lines, it means that purchase specifications must be continually revised.

b) Consulting engineers, architects, manufacturers, and field representatives can institute their own programs of changing design specifications to result in reduced use of critical materials.

Fig. 1 indicates where various types of workers can find their greatest field of activity within the scope of the conservation effort.

Specification

Since opportunities for conservation through specification activities (4-b) are *least* apparent, let us take a moment to outline a few of the

SUMMARY — $125,000 is the estimated cost of killing an enemy soldier ---- an indication of the quantity of material required in World War II, which Donald Nelson has called "the smart man's war". George W. Meek, WPB conservation specialist, explains here the why and how of "all out" conservation in heating and air conditioning work. Substitution, salvage, simplification, and specification are all involved ..... Mr. Meek is assigned by the conservation division of the War Production Board to the commercial refrigeration & air conditioning and the plumbing & heating branches of the WPB. In addition to explaining your place in conservation efforts, his article is important because it undoubtedly may be said to give the background data on which much WPB thinking and many rulings are based. Men in the industry may or may not agree with all the rulings or with the data on which they are based, but here they are.

Fig. 1—The field for conservation activities

Your Job	Substitution	Salvage	Simplification	Specification
Design & Test	× (1st)		× (2nd)	
Production	× (2nd)	× (1st)		
Layout & Sales	× (2nd)			× (1st)
Installation & Service	×			

activities of this type—activities which can result in tremendous savings of copper, steel, cast iron, fuel, and power.

One very good example of the opportunity for a specification saving lies in the practice of calculating ventilation requirements. Over a period of years, consulting engineers, layout men, and sales engineers have gradually fallen into certain standard design practices which have long since been accepted as gospel. As a result, nobody stops to question the desirability of these practices even under changing economic conditions.

For example, it has been common practice to allow from 10 to 15 cfm of outdoor ventilation air per person. We have become so used to thinking in these terms that anyone who would talk about reducing these values to 3, 4, or 5 cfm would seem to have lost his senses. Yet there *is* some justification for this lower figure and the data presented by the curves in Fig. 2 have been prepared for the purpose of clarifying this point. Curve *A* shows that less than 1 cfm per person will provide ample oxygen for an active worker. Curve *B* shows that 3½ cfm per person will serve to keep the carbon dioxide concentration from rising above 1 per cent (a figure generally regarded as providing an ample safety factor). Curve *C* represents the ventilation requirement based on laboratory tests, the results of which are published in the 1942 Heating, Ventilating, Air Conditioning Guide of the ASHVE. It shows the minimum amount of ventilation air which is necessary to prevent objectional human odor concentration from sedentary adults *with little or no smoking.*

Curve *D* has been derived from Curve *C* by allowing 50 per cent more air to provide for the difference in odor generation between a sedentary adult and a worker in a blackout assembly plant. This curve was projected at the bottom because in manufacturing plants it is seldom that there is not at least 1000 to 2000 cu ft of air space per person. (The air space per person may go to as high as 3000 to 5000 cu ft) Notice just how far below the so-called standard ventilation rate of 15 cfm per person Curve *D* falls for "large air space" applications such as industrial plants. There seems to be no justification for using more than 5 cfm per person under such conditions, even with surface type dehumidifiers. (Reference to p. 40 in the 1942 ASHVE Guide shows that with a spray dehumidifier it is possible to prevent odors with less than 4 cfm per person, even with spaces so crowded as to allow only 200 cu ft of air space per person.)

Blackout Assembly Plant

In a blackout aircraft assembly plant (no smoking and practically no industrial odors) using 3 watts per sq ft for fluorescent lighting, density of 80 sq ft per person, and 3 hp of motors per 1000 sq ft, the total air conditioning load (with 15 cfm outdoor air per person) figures 2500 tons. This ventilation load accounts for 32 per cent of the cooling load. If the outdoor air quantities were reduced to 5 cfm per person two-thirds of 32 per cent would show that changing from 15 cfm to 5 cfm per person would reduce the total cooling load by 21 per cent. Thus the total cooling load would be reduced from 2500 tons to approximately 2000 tons. (The heating load may be reduced by 70 per cent, or even eliminated.)* This in turn involves the following savings:

1) Refrigeration plant will be smaller by approximately 39,000 lb of iron and steel, 12,000 ft of copper condenser and cooler tubes, 25,000 ft of copper tubing in dehumidifier, and one 500 hp electric motor or steam turbine.

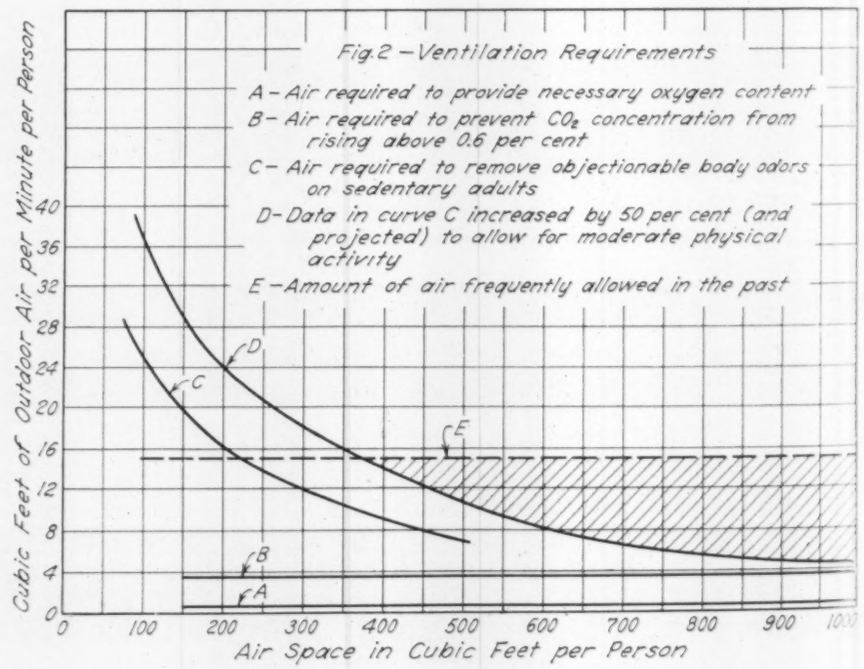
2) Power consumption will be reduced by approximately 800,000 hp-hr per year on refrigerating machines, and 300,000 hp-hr on fans and pumps.

3) Fuel oil consumption will be reduced by approximately 28,000 gal per yr.

4) The materials in the heating plants may be reduced by 45 per cent or more.

Sizable savings? They certainly are. If *you* are a consulting engineer, an architect, a layout engineer, or sales engineer, you can apply this same type of saving to this particu-

*In a blackout plant with insulated walls and roof cooling may be required (with outside air or refrigeration) with outdoor temperatures of 30, 20, or even 0 F, because of the internal heat load. Hence, actual heating requirements are low, and the ventilation load is a large component. Assuming a 100 per cent heating load at 0 F, as much as 90 per cent may be the ventilation air component.



lar type of job whether it is 25 tons or 5000 tons.

(Your attention is called to the peculiar behavior of odors. Body odor rapidly dissipates and *large* air spaces per person are desirable. Industrial odors, such as those from cutting oils, are subject to the usual dilution laws. Burning tobacco odors actually increase in intensity for several hours after their creation and hence results are favored by *small* air spaces per person. Hence if industrial and tobacco odors are prevalent in the conditioned plant the above savings in materials can still be made but it may be necessary to resort to the use of odor adsorbers —and in some cases, electrostatic air cleaners in addition to the odor adsorbers.)

Type of Heating

Another example of conservation savings through carefully considered specification practices is found in the heating field. A critical review of the practices involving the selection of unit heaters, unit ventilators, and cast iron heating devices is quite illuminating. Fig. 3 shows relative amounts of metal used with various types of heating equipment for a given capacity. Of course, the question immediately comes up as to the relative value to the war effort of steel as compared with cast iron. Since both metals make use of pig and scrap and since supplies of both pig and scrap are critical, it follows that rolled steel products and cast iron, while not on a weight parity, are still related in a ratio of probably one to two or one to four.

Another question, that of corrosion, probably also comes to the engineer's mind. He may dimly recall some experience in which a steel tube type convector did not give lasting service. It is true that in the early days there was a great deal of difficulty with corrosion, but these difficulties have been overcome. One manufacturer has thousands of steel convectors that have been installed for 10 years and examination of these indicates that they still have a long life ahead of them.

There is another, and somewhat curious, reason for substituting for cast iron radiation. The manufacturers of radiation were forced by a limitation order issued by the plumbing and heating industry branch of

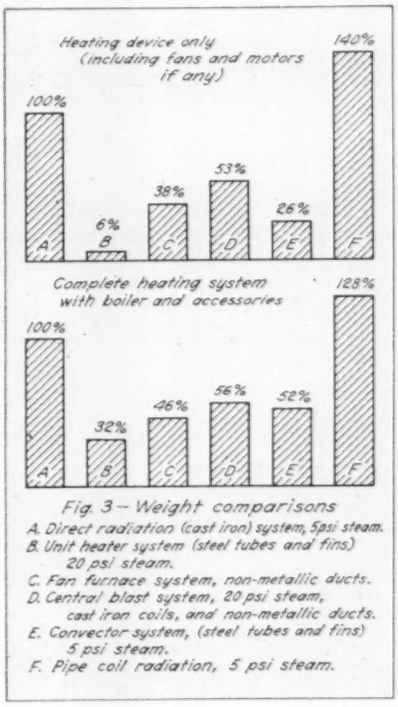


Fig. 3—Weight comparisons

A. Direct radiation (cast iron) system, 5psi steam.
B. Unit heater system (steel tubes and fins) 20 psi steam.
C. Fan furnace system, non-metallic ducts.
D. Central blast system, 20 psi steam, cast iron coils, and non-metallic ducts.
E. Convector system, (steel tubes and fins) 5 psi steam.
F. Pipe coil radiation, 5 psi steam.

the War Production Board to make only the more efficient type of "slim" tube radiation. The demand for radiation for shore bases, hospitals, etc., became so great that it exceeded the production capacity of many companies for certain sizes of this type of radiation. It was not thought desirable to permit them to expend sizable amounts of time and money on new pattern equipment at this time. Hence some of this load is being relieved by an increased use of light weight, extended surface and direct fired furnaces.

Thus it is rather obvious that the considered use of certain types of heating devices presents still another method whereby engineers can help the war conservation effort. Once the mind has been sharpened to the everyday possibilities for "specification" type savings, it will be surprising to note just how frequently opportunities for saving will present themselves.

Substitution

Nowhere is there greater possibility of waging the "smart man's war" than in the case of the design engineer's efforts at substitution. The piles of materials that have remained in some of the warehouses and mills have lulled many designers into a false sense of plenty. The rapid rate of depletion of those stock piles, and the repeated warnings from WPB that what stock piles there are will be urgently needed in the months ahead, have convinced many designers of the imperative necessity of revising existing designs to eliminate the use of critical materials.

What is a critical material? Unfortunately the measure of a material's availability is never taken with a draftsman's scale, a yardstick, or any other finite measuring device. A material is "critical" when its use is essential to the effort at hand, but is not available in the quantities required.

All design engineers have found that their problem is to know what material is *most* critical. As an example, some air cooling coils originally made extensive use of aluminum. When the demand for aluminum exceeded the supply, copper was considered less critical and was used as a substitute. Then when a future shortage of copper became apparent, the coil materials were changed to galvanized steel. But what with the shortage of zinc, even the galvanized coating then had to be changed to a high lead solder. This type of thing has resulted in a nerve-wracking and hair-tearing experience for many design engineers. Some hope is now in sight because, after this early period of rapidly shifting emphasis on the relative shortage of the various materials, we now seem to find the positions becoming more stabilized. As a general thing, any *large* uses of aluminum, copper, tin, nickel, chrome, high alloy steel or iron, brass, zinc, and rubber, are out of the question for refrigeration and air conditioning equipment even if that equipment is for the armed services. This leaves, among the metals, only cast iron, steel, lead, and small amounts of copper and brass for bellows, capillary tubing, fittings and small moving parts, with steel alloys, tin, and copper only for most essential control devices and for current-carrying parts.

Unit Ventilator

But, limited as that selection of materials now appears, we see all about us one evidence after another of where the substitution job is cleverly accomplished. Space per-

mits just one example of the "smart man's" progress in the substitution field. Fig. 4 shows the "before and after" data for a unit ventilator which finds wide use in Army chapels, Army and Navy instruction buildings, industrial offices, etc.

Tar Coating

Of course, "complete elimination" is substitution at its best. Consider the simple matter of the tar coating on cast iron soil pipe. About 65 per cent of the pipe used in this country is coated—the balance being uncoated because of municipal laws in such cities as Philadelphia, New York, and Boston. Since the life of the cast iron pipe is believed to be almost entirely independent of the tar coating, the plumbing and heating branch of WPB has felt that the elimination of a tar coating on *all* cast iron pipe is desirable because:

1) It will relieve the transportation system of hauling more than 600 cars.

2) It will make in excess of 120 cars of coal tar available for fuel or for airport and highway use.

3) It will save approximately 500 carloads of coke, coke breeze, and fuel oil which would otherwise be used in preheating the cast iron pipe and melting the tar.

4) It will remove the necessity for many dealers to carry two lines of pipe—coated and uncoated—and thus reduce inventories by more than 10,000 tons of pipe and fittings.

Thus it is often found that what appears to be a very simple substitution or elimination may prove upon careful analysis to have far-reaching effects.

Simplification

The case for simplification and standardization is almost as much discussed as that of substitution. During the severe competitive struggles that took place within industry in the 1930's there were developed what, under present conditions, often amounts to an excessive number of types and sizes of refrigeration and air conditioning equipment.

Again, just one example will serve to show what is being accomplished. A review of drinking water cooler specifications showed that the Army, Navy, and Coast Guard called for 28 sizes and types of electric drinking water coolers and 18 sizes and types of iced drinking water coolers. The manufacturers and the National Bureau of Standards undertook a careful study of the situation; both served the conservation section of the commercial refrigeration and air conditioning industry branch of WPB in an advisory capacity. Then WPB issued simplification order L-126—schedule 1, with the result that 28 sizes and types were reduced to eight, and these could be built with five basic assemblies. The 18 sizes and types were reduced to three. In the case of electric drinking water coolers, the use of precoolers was made mandatory. Much could be said as to how this reduced the quantities of material in inventory, speeded production, and cut cost.

In spite of the desirability of some of the activities outlined in this article, it is obvious that the lesson of conservation is not an easy one for America to learn. But hard or easy, we have no choice. The great struggle in which we are engaged taxes our every energy. Before our troops on the far-flung battle lines of the world can bring superior force to bear on the enemy, they must be thoroughly equipped with the tools of modern war. The battle of production must be won first. That engagement cannot be brought to a successful termination unless we husband all our resources—steel, tin, rubber, aluminum, and everything.

Let us, therefore, in our all out effort for victory, resolve to be conservation minded. Let us all, like good generals, marshal our reserves of critical materials so that our full striking power can be delivered against the enemy. As individuals, let us detemine to save and sacrifice; as industrialists, let us willingly adopt programs of simplification, substitution and salvage. There are many ways in which each of us may wage "the smart man's war."

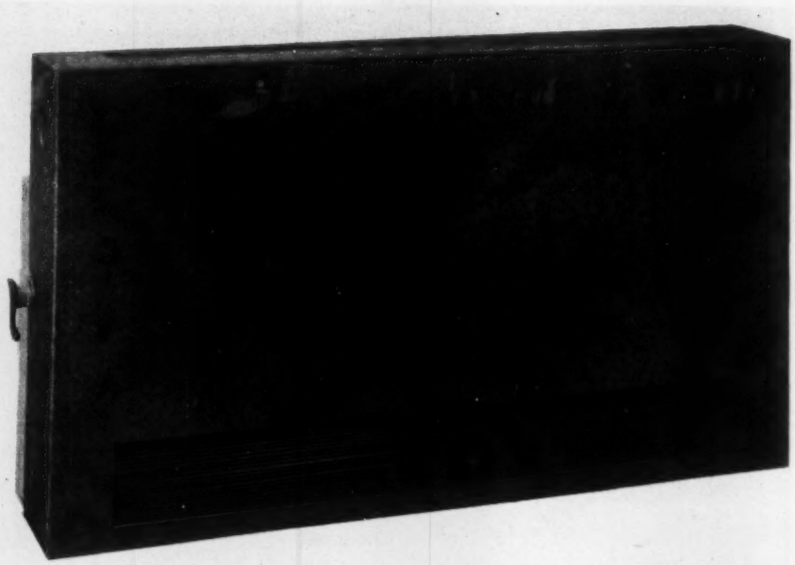


Fig. 4—Figures used by WPB on weight of metal (in pounds) required for a unit ventilator—widely used by the Army, Navy and in industrial offices—before and after conservation by substitution

BEFORE	MATERIAL	AFTER
476	Steel	145
12	Cast iron	12
8	Copper	8
496	Total metal	165*
1560	Cfm	1560
526	Capacity, EDR	473

This weight reduction was accomplished by substituting wood and various wood type products for steel in the following parts: entire exterior casing including grilles, interior chassis or frame, motor and fan assembly plate, outside air intake box, and damper assembly.

*By comparison, the installed weight of equivalent capacity cast iron finned convectors with additional piping, valves, and traps would be approximately 1740 pounds, according to WPB figuring.

Completely Conditioned Manufacturing Building Has Fifty-One Separate Zones

Steam Turbine Driven Compressor and Well Water Supply Refrigeration for Air Conditioning Units Throughout New Plant — By J. Thomas Browne and Raymond C. Carlson

SUMMARY—A new manufacturing building, engaged in wartime production, is completely air conditioned by a system comprising 51 separate zones, each with its own air conditioning unit controlled independently of any other unit. Chilled water is supplied the units from a central refrigeration plant consisting of a turbine driven centrifugal compressor providing 680 tons of refrigeration capacity, supplemented by 52 F well water which brings the total refrigeration capacity to approximately 945 tons. . . . Exhaust steam for winter heating and humidification is supplied the units from a uniflow engine driving a generator which furnishes the direct current for the plant. . . . The units are either of the outside air or recirculating types, the advantage over having combination units being one of control; inasmuch as the internal latent load is quite small for most sections of the building, it is possible to obtain the required amount of humidification throughout by controlling the outside air units only. Air from the units goes to the spaces served through duct work, and both ceiling and wall type aspirating air diffusers are used. . . . Because of the large amount of exhaust required by the plating department, the coils of the plating room units receive water which has already gone through the coils of other units. By so operating, a considerable amount of sensible heat is removed from the plating room air, but it is not possible to maintain the same relative humidity conditions there as exist in other parts of the plant under maximum design conditions. . . . The authors are on the mechanical engineering staff of the owner of this new plant

Glass block windows are used throughout, except for a section at sight level, which is made of double clear glass. The roof is of the sawtooth type, with glass blocks in the vertical section. Wall type air diffusers are used on the top floor to distribute the air evenly in the working area without unduly disturbing the upper air in the sawteeth of the roof

A NEW wartime manufacturing building, recently completed, is air conditioned throughout. It is built of reinforced concrete, and has glass block windows (except for a section at the sight level, which is made of double clear glass). Three complete floors (including the basement, which houses the heat treating, screw machine, and tool stores departments) are used for machining, heat treating and plating, while a penthouse section at the front of the building is occupied by offices and the drafting room of the planning department. The roof over the second story is of the saw tooth type, with glass blocks in the vertical section. Since this section faces the north, there is uniform light all day.

51 Zones

The entire building is divided into 51 separate zones, each with its own complete air conditioning unit controlled independently of any other unit. Thus flexibility is insured to meet any condition of loading which now exists or which will arise in the future.

The refrigeration capacity of the system is approximately 945 tons. Air is circulated at the rate of 400,000 cfm, giving about 10 air changes per hr for most sections of the building. Outside air makes up about 25 per cent of the total air circulated, except in the case of the plating department which receives special treatment as will be described later.

10 In. Pipe Lines

The refrigerating equipment for the air conditioning system is in a room adjoining the plant engine room, and is about 500 ft from the manufacturing building. From this point, over 1600 gpm of cooling water is circulated by means of two 10 in. water lines. Of this total, about 45 per cent is drawn off and replaced by well water, while the

remaining quantity is continually recirculated.

Exhaust steam for winter heating and humidification of the air supply is furnished to the units by means of an 18 in. main which follows the same path as the water lines. This steam comes from a uniflow engine which is used to drive a generator furnishing all of the direct current for the plant.

Turbine Drive

The water cooling system consists of a centrifugal "Freon" compressor driven by a steam turbine operating between a head pressure of 2 psi ga and a vacuum of 26 in. of mercury. The speed of the compressor is automatically controlled in accordance with the demand for refrigeration. The turbine, running at 3650 rpm, develops 485 hp. The capacity of the "Freon" compressor is 680 tons of refrigeration, the balance of the refrigeration being made up by well water.

Mixing Well Water

At this point it may be well to describe the water circulating system and how the well water is mixed with the recirculating water. Seven hundred gallons of 61 F water per minute is removed from the return line at a point before it enters the unit circulating water pump in the refrigeration room. This is replaced by an equal amount of well water at a temperature of 52 F. This mixture of water goes to the "Freon" water cooler, where the temperature is lowered to 47 F before it is sent through the supply line to the air conditioning units in the new building. The 700 gpm of water which is removed from the return line is mixed in a special mixing tank on the suction side of the condenser circulating pump with 850 gpm of water from the barometric condenser discharge line of another air conditioning system, and the resulting 1550 gpm of water, at a temperature of 71 F, is sent first through the "Freon" condenser and then through the steam condenser, after which it is discharged to the sewer.

The water line is so valved that in case of failure of the refrigeration system, the water cooler can be bypassed and cooling done entirely with well water. The condenser circulating water pump is driven by a 40 hp motor, while the air conditioning unit circulating water pump requires a motor of 100 hp.

Air Diffusion

The units supplying the planning department in the penthouse are of the combination outside air and recirculating air type, all other units in the building being either entirely outside air or entirely recirculating air units. Air from these units, which are situated in a space above the office, is carried by duct work to a group of aspirating, ceiling type, diffusers which distribute the air evenly to all parts of the department, thereby equalizing the temperature throughout the conditioned space. The characteristics of these diffusers are such that approximately 35 per cent of the room air is drawn into the devices, where it is mixed with the supply air before the latter is discharged. This mixing of room air with the supply air causes the predetermined condition of the air to be established well above the breathing level.

The quantity of air circulated is constant whenever the space is occupied. However, during the winter night periods, holidays, and weekends, a thermostat operates the fan motor only when heat is needed and under these conditions the unit operates as a recirculating unit. This method of operation results in a saving not only of power, but also of steam. The change in method of operation is accomplished merely by the closing of the master pneumatic air valve, which is situated in the basement. The operation of this valve closes all outside air dampers, stops all outside air fans, and closes all humidifier valves. This is true of all outside air units in the building except four which are converted to recirculating units by this operation. In the case of the four units the closing of the master air switch opens recirculating air dampers.

Second Floor Units

The second floor of the building is occupied by the milling, special production, drilling, and tool making departments. This area is served by 18 units, four of which handle all outside air and 14 of which handle all recirculated air. The humidity of the entire space, which contains no partitions, is controlled by the outside air units which are uniformly placed. All second floor units are situated in narrow corridors or passages which run along either side of the building at the roof level. These corridors serve also as distribution passages for steam lines, water lines, and duct work, thereby improving the appearance of the second floor by eliminating these items. Return grilles are beneath the filter boxes of the units in the floors of the corridors. Air from the units is distributed to duct work which runs across the building below the glass block in the saw teeth and against the steel framework. Each bay has four wall type air distributing outlets across a width of 143 ft, the bays being spaced 25 ft apart. In all, there are 72 wall type air diffusers serving the second floor, which has an air circulation of 150,000 cfm. These wall diffusers function in the same manner as the ceiling diffusers installed throughout the rest of the building.

The First Floor

On the first floor are the gear cutting, grinding, bench work, and plating departments. Here also are the toilet and locker rooms for the

workers of the first and second floors. The plating section is separated from the rest of the machining section by a glass block wall. The machining section has 14 units, of which 10 handle recirculated air and four provide outside air. The advantage in having units of either the outside air or recirculating air types rather than combination units is one of control. Inasmuch as the internal latent load is quite small for most sections of the building, it is possible to obtain the required degree of humidification throughout by controlling the outside air units only.

In general, floor type units are used. The exceptions to this are two central systems, one supplying most of the outside air to the basement and first floor, and the other supplying part of the outside air to the plating department.

The units on the first floor are placed against the stair tower walls. Each discharges into a system of overhead duct work which is flush with the ceiling and which is connected to several aspirating type ceiling diffusers similar to those installed in the planning department. Return air ducts are eliminated since the return grille is at the unit in each case.

The first aid department, on the first floor, receives all outside air from a basement central system; all of this air is exhausted from the various rooms of the department by means of a central exhaust system with a fan on the roof of the building. In this way the first aid section is always insured of a supply of outside air, and air from the first aid department is never intermixed with air from the rest of the plant.

Plating Section

The plating department, which occupies the northwest section of the first floor, receives 52,000 cfm of outside air. This is enough to change completely the air in the room every three minutes. This large quantity of air is needed to replace the air that must be exhausted in connection with plating and polishing operations.

Inasmuch as the quantity of exhaust is so large, it is not desirable for obvious reasons to condition the air supply for the plating department to the same degree as is the air for other sections of the building. Therefore, the coils of the plating room units receive water which has already gone through the coils of other units. Under conditions of maximum design, the water leaving the coils of the regular units has a temperature of 60 F. The temperature of this water is allowed to rise 10 F in going through the plating room unit coils, increasing the temperature of the entire quantity of water returning to the refrigeration room by 1 F. By so operating, a considerable amount of the sensible heat is removed from the plating room air, although it is not possible to maintain the same conditions of relative humidity that exist in other portions of the building when maximum design conditions exist outside. The entire supply of air is handled by three units, one of which can be converted to a recirculating unit to supply heating or cooling to the area when the department is not occupied and when outside air is not required. Under these conditions, the other two units do not operate, having been shut down by the operation of the master air switch.

Here is one of the air conditioning units, which is furnished chilled water in summer from a central refrigeration plant, and exhaust steam in winter (for heating and humidification) from a uniflow engine. Ceiling type air diffusers are used in this section

Exhaust Fans

Several exhaust fans on the roof of the building serve to ventilate toilet and locker rooms and the transformer vault. Air for these sections is taken from the general room air through door louvers to exhaust grilles in the side walls or ceilings of these rooms. In the case of the locker rooms, the quantity of exhaust air is sufficient to change the air 10 times per hour. The transformer vault exhaust system insures enough room air being drawn through the vault to prevent the temperature in that space from exceeding a predetermined level.

Units in Basement

In the basement are 13 units, of which nine are of the recirculating

type and four are of the outside air type. Here again most of the units rest on the floor against stair tower walls. Floor type units were selected because they are readily accessible for repairs, adjustments, and filter changing; then, too, the return grille is in its proper position without the use of return duct work. By placing the units at stair tower walls, long runs of ceiling piping were eliminated since shafts in the stair towers were used as passageways for pipe lines.

The outside air central system for the basement and the first floor is situated in the basement. Bringing in all the outside air at one point eliminated cutting numerous small openings in the wall to admit air to a number of individual units placed at various positions on the floor. In this particular central system the total quantity of air is preheated and filtered, after which it is divided into six parts and sent to six different zones. Each zone has its individual thermostat and humidistat controlling its own heating coils, cooling coils, or humidifier in accordance with the requirements of the space.

Instruments

There is a resistance thermometer and dial switch in the outside air central room. By means of this instrument the operator is able not only to read the outside temperature, but the wet and dry bulb temperatures at two points on any floor in the building as well. Thus, the operator is informed at all times of conditions in any part of the building. In addition to this thermometer, there are in the engine room instruments for measuring the quantity and temperature of chilled water to and from the units, the quantity of low pressure steam for heating, and the quantity of low pressure steam for operating the "Freon" compressor turbine.

Each individual unit throughout the plant is fitted with the necessary shut off valve so that the whole unit may be shut down for adjustment or repair without disturbing any other part of the system.

In order that the filters shall be cleaned only when necessary and at the proper time for efficient operation of the system, a draft gage and pitot tube has been installed on each air conditioning unit so that the pressure loss through the filters can be readily determined by the operator.

Controls

All automatic controls are pneumatically operated. In the summer, a temperature of 75 F and a relative humidity of 53 per cent is maintained throughout all portions of the building whenever the outside temperature is below 85 F. When the outside temperature goes above 85, a 10 F differential is automatically maintained with corresponding relative humidity to produce the proper effective temperature. In the winter a temperature of 72 F and 45 per cent relative humidity is maintained. Whenever conditions outside are such that a relative humidity of 45 cannot be held, the greatest relative humidity that can exist without causing condensation is automatically maintained by the control instruments.

During winter nights, and week ends, a temperature of 65 F is maintained. During these periods when the building is not occupied, no outside air is introduced into the building and the recirculating unit fans run only when heat is required.

The quantity of cooling water in the system is constant at all times. The amount of water going through the coils of an individual unit is controlled by a three way valve operated by the thermostat and humidistat in accordance with the requirements of the particular zone. Heating and humidification is accomplished by steam, the quantity of which is controlled by zone thermostats and humidistats operating throttle valves.

Unit for Heat Transfer Rates

A CURSORY examination of the literature discloses some 20 composite units in recent use for heat transfer rates, according to Lionel S. Marks, professor of mechanical engineering, emeritus, Harvard University, in a recent issue of Mechanical Engineering. This condition imposes unnecessary hardship on one who seeks to know the heat transfer coefficient to employ under given circumstances. The values which he will find in various books and other publications are not directly comparable until reduced to some common unit. Moreover, the current confusion leads frequently to error through an inaccurate assumption as to the time unit. It appears desirable to establish some common unit in which to state the results of all heat flow investigations, according to Professor Marks.

The watt, with its multiples and submultiples is the logical and convenient unit for stating energy flow rates. Its use will simplify the statement of heat transfer; for example, a conductance of x Btu per sq ft per sec becomes y watts per sq ft. The conversion from any of the older composite units to watts is made by a simple multiplication by a conversion factor. The values of these conversion factors are as follows, the calorie being the IT calorie and the Btu, the ASME Btu:

1 kilocalorie per second = 4.186 kilowatts.
1 kilocalorie per minute = 69.78 watts.
1 kilocalorie per hour = 1.163 watts.
1 Btu per second = 1.055 kilowatts.
1 Btu per minute = 17.58 watts.
1 Btu per hour = 0.293 watt.

The main committee on power test codes of the ASME has taken action in this matter by adopting the watt (with its multiples and submultiples) as the preferred unit in stating heat transfer rates and is drawing the attention of its individual committees and of other interested groups to this unit. It is not the intention of the committee to ask any writer to abandon the unit to which he is accustomed. It is proposed only that in addition to such unit he will present his heat transfer data in the preferred units—in parentheses or otherwise. By this procedure, all values can be immediately compared without the labor and the possibility of error involved in conversion to some common unit.

GET IN THE SCRAP!
SALVAGE
FOR VICTORY

Operating and Maintenance Engineers Have Vital Job To Do in Wartime

Lester S. Ries Describes Increased Importance of Maintenance at Institutional Buildings to "Keep 'Em Operating" . . . . . Heating and Ventilation Need Special Attention

SUMMARY—The things we now own are the most valuable we have ever owned, for the demands of war come first. Maintenance organizations at institutional and other buildings must therefore give increased attention to the equipment in their charge. The problem is further complicated by trained men leaving for the armed services or war production industries, and in some cases by increased demands on the building services. . . . Mr. Ries, superintendent of the department of buildings and grounds at Oberlin College, summarizes his conclusions as follows: (1) Every effort should be made to maintain buildings in a state of repair sufficient to keep out weather and prevent hazards. (2) Replacement labor will probably be inferior to the regular staff and greater responsibility therefore must be assumed by foremen and other key men. (3) Plans should be made to employ women in maintenance organizations wherever possible. (4) Continuing emphasis must be placed on careful inspection of all mechanical equipment and machines. (5) A continuing effort must be made to familiarize everyone regarding the needs for conservation in order that the things we now have will last

IT HAS been truly said that during the war, the things we now own are the most valuable we have ever owned. Maintenance organizations thus are faced with the necessity of giving increased thought and attention to maintaining their equipment and services in good order. Virtually each day confronts us with another shortage and restriction due to the impact of total war. Irrespective of priorities, it is the function of the maintenance department to "keep 'em operating"—often with greater demands being made on the equipment during this emergency period than during normal times.

In approaching this problem, it is necessary to make a survey of the wartime needs of mechanical equipment and services. This can best be achieved by requesting each foreman to look over, critically, the equipment and services under his supervision, listing any changes in the load borne by this equipment and revising schedules of inspection and operation in terms of the new needs.

Institutions situated in great industrial areas are in the position of having their good mechanics attracted to concerns manufacturing munitions. Replacement of such men is difficult and institutions will no doubt have to be satisfied to redistribute the duties of their staffs in such manner as to place the greatest responsibility for maintenance of equipment and services in the hands of the older men who in all probability will remain. As key men leave, it is necessary to revise the duties of many of the jobs and (with the help of foremen and service men) redistribute the work.

Certain basic principles should be followed in order to interfere least with the war effort: (1) Institutional building maintenance organizations should adopt the principle that all work involving nonessential major alterations or new projects should be deferred for the duration. (2) The exteriors of buildings—the roof, windows, walls, etc.—should be kept in good repair. (3) Whenever possible, in order to hold jobs for the men who have gone into the armed services, the personnel replacement in the maintenance organization should constitute older men or possibly men recalled from retirement.

Emphasis must be placed on careful inspection of all mechanical equipment. When air washers are shut down, the water should be drained and a check for defects should be made

In some cases, changes required due to the war call for modification and alteration in existing building space at a school or university. It has often been found, in cooperation with the faculty, that existing space can be rendered adequate for the changed use by modification of present equipment. It is important to evaluate each change required in terms of the present installation. It is surprising how a physics laboratory, for example, can be adapted with some ingenuity for classes in gas engine maintenance and operation without much alteration.

Ventilation

In order to insure the uninterrupted operation of ventilating equipment the engineer is required to be constantly alert for any suggestion from the sound of the fan in operation, or the overheating of a bearing, or the sputtering of lubricating oil, that some repair is indi-

cated. The safest policy is to shut down equipment whenever such need of repair is noted in order that no large or unnecessary repair will be required. During a normal college year, every effort is made to keep the ventilating equipment in operation for the heating season, and when idle, to overhaul it adequately. Now, however, there are no idle periods, as colleges are in session 12 months of the year. In case of air washers, as soon as the need for their service is over, the water should be drained from them and the equipment checked for defects.

The electrical maintenance crew should inspect the motor equipment as normally, but with a keener eye for small indications of distress. Those motors loaded to capacity or a little beyond should be given special attention so they may continue to give satisfactory service. The same type of care should be exercised with refrigeration equipment, elevators, pumping machinery, etc. Hot water and cold water storage tanks should require more frequent inspections than normally and greater care exercised in seeing that the insides of such tanks are adequately lined with cement or paint, as the case may be, so that spot corrosion will be reduced to a minimum. Air filters must be carefully checked for sludge accumulation in the oil reservoir, and every effort made to keep this equipment in top-notch operating efficiency. By so doing, the dual advantages of reducing interior decorating and cleaning costs and maintaining the proper air distribution are achieved.

The things we now own are the most valuable we have ever owned, and they should be cared for properly. This picture shows the inspection and cleaning of blades in a ventilating fan

Conservation

Along with this prevention effort, conservation of all supplies and services should be vigorously advocated. A conservation council is functioning in most cities, and supplementary councils are operating at most institutions, for the duration. To this council are brought suggestions for the reduction of service and supplies, and if these suggestions have merit they should be given extensive publicity. As with most committees, however, the responsibility for conservation falls on the committee members themselves.

Through this council, cooperation should be sought in reducing wastage—for example, waste due to heat loss through open windows and doors, greater care in the use of hot water, discrimination in the use of paper towels, office supplies and disposition of litter. Public displays can be made interesting and should be arranged by illustrating "critical" items, explaining the difficulties which have developed in procurement of specific items. Through these displays, a plea should be made requesting the public's cooperation in lessening the use of "critical" materials. In order to be effective, these displays must be changed frequently.

Most maintenance men have reduced considerably the use of private automobiles in connection with their work. Bicycles have been purchased for the use of key men at some institutions to encourage the laying up of automobiles for the duration. However, some sort of protection will have to be developed for the men in inclement weather.

PULVERIZED COAL BY STEAM EXPLOSION

That coal so finely pulverized as to be suitable for burning under boilers can be produced by the sudden expansion of steam within the pores of the pieces of coal has been proved in a program of research recently sponsored by the Peabody Coal Co. at the Armour Research Foundation, according to Bituminous Coal Research. Based on principles similar to those used to make "Puffed Wheat," coal was shot from guns in which it had been subjected to steam at high temperatures. While in the gun, the pores become filled with water or steam at the same temperature and pressure as that of the steam around it. When the pressure in the gun is suddenly released, the pressure within the pores of the coal explodes it into small particles.

Because impurities such as bone and pyrites are much less porous than the coal substance, the reduction in the size of the pieces of ash forming materials is much less than for the coal. Thus, the coal is not only pulverized but it can be cleaned in the same operation.

In their early experiments, the investigators used a heavy wall tube filled with coal and water and sealed at one end by a thin metallic disc so selected as to rupture at some preassigned pressure. The tube was heated by an external electric winding and the water converted to steam; when the latter had reached the given pressure, the seal broke and the sudden expansion of the steam resulted in a bursting of the coal pieces and their ejection from the tube into an open receiver.

Results were so promising that a new tube was built with a hydraulically operated, quick opening valve to replace the rupture discs and a special high pressure steam boiler was provided to furnish steam under controlled conditions. The arrangement made it possible to study the effect of steam pressure, time of soaking, and quickness of release on the yield of fines obtained. Discharge of the coal against a target increased pulverization.

"OPEN FOR DISCUSSION"
Communications to the Editor

AIR IN AIR RAID SHELTERS

THE EDITOR—

I was interested in Mr. Fleisher's article on air in air raid shelters published in the July HPAC.

While the article admits that a temperature rise of between 200 and 300 F is ridiculous, the article is misleading in that, under the conditions of sedentary occupation assumed, the sensible heat would be only about 225 Btu per hr at a room temperature of 79 deg and would rapidly fall off to zero when the air temperature reached the body temperature of the occupants, which is normally 98.6 F. It is true that the condition of occupancy might cause the body temperature to rise above normal, but there are few cases where persons have survived with a body temperature of 110 F and the usual limit is from 106 to 108 F.

Since the article is based upon the temperature rise in the shelter being due to the metabolic output of the human occupants, it would be impossible for the inside temperature to rise above a range of about 110 F.

The proposed arrangement of the garage shelter does not comply with accepted standards for the number of occupants within one protected area. The British standards, which are also recommended by authorities in this country, establish the desirable maximum number of persons within one protected area at 50 with a top limit of 200. They also require that the dividing wall between compartments for 50 persons or less be 12 in. of reinforced concrete or its equivalent and, where more than 50 persons are in a compartment, the dividing wall shall be 24 in. of reinforced concrete or its equivalent.

The reason for limiting the number of persons within one protected area is obvious, and that is to avoid such heavy casualties as would result if the protected area received a direct hit. The loss of life in such a case would be bad enough, but the effect upon morale would be even worse.

Overhead protection from a 500 to 600 lb medium cased high explosive bomb could be obtained along the lines suggested. However, when it is realized that it requires a concrete roof and five or six concrete floors to provide reasonable protection from a 500 to 600 lb medium cased high explosive bomb, it is obviously out of the question to provide overhead protection for the larger bombs of this type, which may weigh up to 4000 lb.

The fact that bombs, unless dropped from extremely high altitudes, do not fall in a vertical direction but at a considerable angle, depending primarily upon the height and speed of the plane, is frequently overlooked. It is, therefore, obvious that there is considerable possibility of a side wall hit with the consequent penetration thereof.

It is apparent that any shelter area is subject to possible penetration by and explosion from either overhead or side wall hits and consequently it is considered imperative to avoid too many persons within one protected area.

The idea of dual purpose structures is worth serious consideration in peacetime, in order to provide for protection in event of war. However, since we are now in the war, it does not appear at all feasible to consider such means of protection.

The war cannot be won by defensive measures, but must be accomplished by determined aggressive action. While it is imperative that as much civilian protection as possible be provided to maintain civilian morale and productive capacities, so essential to supplying the armed forces, this protection cannot be obtained by means that would hamper, in any way, the general aggressive war effort.

Very little reflection is necessary to see what a load would be placed upon the building industry and the labor supply if air raid shelters of the type suggested, or in fact any type, were started simultaneously to provide protection for only those in the congested urban districts on the seaboard, much less for the country as a whole. Such a procedure would so hamper the general aggressive war effort that it is entirely out of the question.

A fair amount of protection, with relatively little expenditure of materials or labor, can be provided the civilian population, particularly in districts with large fireproof buildings, if proper discretion is used in selecting the areas of refuge. These, of course, will not give all of the protection that could be provided if materials and labor were of no moment, but it is the best that can be done under the circumstances, and is certainly the desirable procedure to follow in order to bring the war to a successful conclusion.

The above suggested procedure does not infer that the heating and ventilating engineer is thereby left out of the picture. On the contrary, there is still the question of providing shelter areas with sufficient air and means of dissipating body heat to make the occupants thereof reasonably comfortable for the length of time they will have to stay in the shelter areas. There is entirely too little authentic information on this subject and herein lies the real opportunity for the heating and ventilating engineer.—JOHN K. PEEBLES, JR., partner, Baskervill & Son, Architects.

Readers of HEATING, PIPING & AIR CONDITIONING are invited to contribute their views to "Open for Discussion," which will appear from time to time.

THE EDITOR—

Thanks for sending the copy of Mr. Peebles' comments on my article, Air in Air Raid Shelters.

In the first place, remember that I returned from Europe first in April, 1938, and secondly, in April, 1939. At that time you could no more persuade the people of the United States that they were threat-

ened with war than you could move the pyramids in Egypt. I felt definitely that sooner or later we would have to have protection against possible air raids because I had been so close to those interests in Europe that knew much more about the situation than seemingly the people of the United States were willing to admit. I assumed the responsibility of attempting to awaken the American public.

I recognized, when I was investigating air raid shelters in Europe during that period, that underground shelters, particularly for long periods or if threatened by poison gas, were absolutely the improper types of protection for the people and all of the authorities in Europe agreed with me — for instance, that subways were death traps. I made up my mind that people would have to seek shelter above the ground, preferably 30 ft up in the air, where the problem of ventilation would be simpler and the danger from poison gases negligible. I also realized that it would be impossible at that period, when people were living on "wish fulfillment," to get them to make radical changes in their existing buildings to ward off the danger or emergency which they were not willing to admit was likely to occur. At the same time, I realized that there was a very definite peacetime problem in our cities of automobile congestion in the streets and if I could combine two requirements in one, I would be doing not only a good thing for the nation from a war angle but also from a peacetime requirement.

I, therefore, combined my ideas in the multistory garages and indicated that these had an economic return which would warrant the municipalities and the government subsidizing their construction. I was and am perfectly familiar with the ARP requirements on the density of population in an air raid shelter but I saw no necessity in projecting this multistory, multi-use garage to start dividing up my floors in such small sections that only 50, 100, or 200 people could occupy an unobstructed portion.

In my original lectures I stated very definitely that the probability of a structure of this kind being safe from 4000 lb bombs making direct hits was not too great, but that it was safer than anything else and consequently gave to the public who had to go to work the feeling of security which was required for psychological equilibrium. Fortunately, the ideas that I broadcast from coast to coast and from Canada to Texas have been followed out. The third floor and upwards has been adopted as the proper place for air raid shelter in multistory buildings. I take full and undivided credit for having put across this idea.

In time of war during air raids *everybody* will never be safe. A good many people will escape. This has been indicated by all of the happenings in Europe but I do feel that my ideas have saved America from foolishly digging up our streets and attempting to use our needed material for pill boxes which would have been impractical and impossible to obtain.

As to the question of a rise in temperature: I said that theoretically 50 cfh of air per person in 54 cu ft, which was the amount of space allotted per occupant in a good many of the shelters, would give a theoretical rise from 200 to 300 F. I did not say anything about the total of 400 Btu's, which is the metabolic output of a person at rest, being responsible for this rise in temperature. As I have had a great deal of experience in fever therapy, I am also aware of the fact that people cannot survive whose body temperature rises to 110 F and remains at that temperature for many minutes. As I have been chairman of the technical advisory committee for air conditioning in industry of the American Society of Heating and Ventilating Engineers for many years, I am also perfectly familiar with conditions of temperature and humidity which cause a physiological change in human beings. When you are dealing with the public on a subject which they are loath to accept, it is essential to emphasize those facts which will awaken them to the necessity of doing something. In briefing this article for your magazine, any number of the facts have been omitted and properly so.

I am happy to say, however, that my efforts to inculcate sensible ideas in the matter of civilian protection from air raids have borne fruit in practically all of the activities of the OCD.—WALTER L. FLEISHER, consulting engineer, president of Air & Refrigeration Corp., and member of HPAC's board of consulting & contributing editors.

OPERATING ROOM AIR CLEANED ELECTRICALLY

AN IMPORTANT feature of a recently completed, 250 bed hospital is the first full scale application of electrostatic precipitation for cleaning ventilating air in operating rooms.

Authorities of the hospital recently purchased an air cleaning unit with a capacity of 18,200 cfm. The unit, consisting of a single bank of 24 cells, is installed between steam heating coils and the washer in the air duct carrying outside air into the hospital. Air circulated to the operating rooms, which occupy three floors of one wing of the 10 story building, is cooled in summer by four 25 ton compressors that serve other units of the hospital. Temperature and humidity are maintained at predetermined levels by automatic control, and air is not recirculated.

Photo courtesy Westinghouse

NAVY RECREATION BUILDING HEATED AND COOLED

UNUSUAL PROBLEMS in heating and air conditioning faced engineers recently in the construction of the recreational building at a large southern naval base. Short period operation of the air conditioning, a greatly varying internal heat load, and high humidity and temperature conditions in summer months were some of the problems.

The recreational structure does many jobs. It serves alternately as a church, motion picture theater, assembly hall, ballroom, club house, and game house, and seats a maximum of 800 persons. Each phase of the cooling-heating system needed to be built for maximum efficiency at short period operation, inasmuch as the building is in use only a short period of each day. Provision was made to heat or cool the building swiftly for an hour or more before occupancy.

To meet these conditions there was installed a combination cooling, heating, and ventilating system that distributes conditioned air. A steam coil preheater for cool days, and two gas fired unit heaters combined with the steam coil for bitterly cold days, are included in the equipment, in addition to the air conditioning system of 50 ton cooling capacity.

Higgins Industries installed the compressor and evaporative cooler in a small room built on the side of the building near the stage, occupying only about 45 sq ft. Direct expansion cooling coils, fan, and mixing chamber are on a platform constructed of heavy timber over the stage where it is out of the way. From this point cooled air passes through ducts in the attic over the auditorium seating space, branching to six ceiling grilles which "mushroom" the cooled air gently over the whole space. A small take off duct delivers cooled air to the space under the balcony, which seats approximately 150 persons. A short intake duct at the fan housing permits 100 per cent outdoor air if desired.

There are three banks of direct expansion cooling coils in the mixing chamber on the platform over the stage. Return grilles are at either side of the stage, and contain thermostatic controls. Under ordinary circumstances a part of the air will be recirculated, with the amount of outdoor air admission regulated according to the number of people in the building. This made it possible to use four step refrigeration, whereby the compressor operates at 20, 30, 40, and 50 ton cooling capacity according to the heat load. For most lectures, motion picture use, etc., the compressor will use 30 or 40 tons; at peak demand, 50 tons.

Auxiliary winter heat is provided by two separate systems to compensate for varying circumstances. There is one large gas unit heater at each side of the stage, with separate ductwork and grille down each side of the building. With 100,000 Btu heating capacity each, these will rapidly heat the building. Heating is thermostatically controlled, regulators being installed in the return air ducts at the floor level in front of the stage. However, during periods of intense cold, when the building is crowded, a large percentage of outdoor air must be admitted to dilute any odors. Provision for this is made by an outdoor air intake at the side of the building which contains a preheater steam coil, using steam from a low pressure, gas fired steam boiler in the basement. Air passed over this coil is warmed sufficiently in cold weather to allow the gas heaters to handle the heating load while admitting 50 per cent or even more outdoor air. During mild winter conditions, the steam coil will be sufficient to heat the building.—O. E. GAMMILL, JR., New Orleans manager, Carrier Corp.

INDUSTRIAL SALVAGE PROGRAM LAUNCHED

AT THE first meeting of the newly organized industrial salvage committee for machinery, instruments and electrical equipment of Greater New York, the crucial need for scrap materials was stressed by R. Merrill Decker, regional manager of the industrial salvage section of the War Production Board.

"We are charged with the responsibility of developing salvage programs for waste materials, especially right now, iron and steel scrap, nonferrous metals, cotton and woolen rags, paper and rubber wherever they can be found. We are concerned with trying to get a larger, faster flow of scrap from industry. Our industrial salvage job is separate from the household salvage campaign," he said.

"Scrap as such is only a small part of the material that can be salvaged in the average plant. Actually, all of the materials in a plant, fabricated or not, are now considered scrap if they are not providing a useful service in an efficient manner. Examples are old models of machines long superseded but held for records, unused stockroom shelves, unused supplies in storage yards and idle valves and fittings.

"Briefly, the objectives of this committee are, the wrecking of abandoned and obsolete machinery and equipment, utilization of all critical materials to the best advantage, minimization of waste and spoilage, re-use wherever possible of blanks, cutdowns, short ends, and clippings, selective handling and segregation of scrap at the source, avoidance of scrap contamination, and speeding the return of scrap and waste through existing channels to mills and refineries."

ORGANIZED MAINTENANCE KEEPS WHEELS OF INDUSTRY TURNING

THE MAINTENANCE department in industry today has a vital responsibility in our war effort to keep hard-pressed equipment in operation during the 168 hr week. This has increased our maintenance problem many times and those who are responsible must think fast and keep prepared for any eventuality.

We must not only consider machine tools, but also our power plants supplying steam and compressed air to the many tools in our shops, as this service is equal in importance to maintaining machine tools and allied equipment. It would do little good to have machine tools in A-1 condition only to be shut down due to a breaker failure in the electrical circuit.

Our main plant has five separate divisions—motor, transportation and generator, switchgear, feeder, and factory service. All except factory service are engaged in manufacturing. The latter services and maintains buildings and service lines, such as water, gas, steam, air, and electric power, and is responsible for repairs of cranes, hoists, elevators, and major rearrangements of departments and equipment. This division also has the responsibility of generating all steam and air and distributing it to the shop.

Each division maintains its own machine tools and manufacturing equipment except where the repair is too large, in which case it calls upon the factory service division to make the repair.

In each of the divisions listed, a tool supervisor is responsible to the superintendent of the division for keeping all equipment fit to meet the production schedules. Each supervisor has his own tool maintenance department with several inspectors who are continually inspecting machines. All tools are checked monthly for any defects that may have occurred, and observations are made on an inspection card, in duplicate.

All motors and controls for machine tools are inspected, repaired, cleaned, and oiled by electricians known as "trouble shooters". These men have their zones laid out and are continually on the alert to keep the electrical equipment in good working condition. If an unusually large amount of electrical trouble occurs in any particular zone, we can point our finger of scorn at the trouble shooter and tell him to get busy. With this setup, we have had very few electrical breakdowns.

Due to the size of our works, each division has a committee for good housekeeping; this committee makes a monthly inspection tour, checking each department in the division and bringing to the attention of the superintendent the conditions of safety, cleanliness, poor lighting, floor loads, explosive hazards in ovens and furnaces, and fire hazards. In addition to these five committees, there is a general committee which makes periodic inspections of the whole plant, covering practically the same points as the division committees. In this way we keep a double check, and we are getting real results in good housekeeping, and safety first.—A. HECKMAN, works engineer, Westinghouse Electric and Mfg. Co., at the American Management Association.

INDUSTRIAL CONCERN CONDUCTS SALVAGE CAMPAIGN IN HOME COMMUNITY

HOW AN industrial concern enabled its home community to establish what is believed to be a record for the salvaging of materials for war use is disclosed in a brochure just issued by Lukens Steel Co., of Coatesville, Pa. — a brochure that well might serve as a "how to" blueprint for the guidance of other enterprises in other communities.

In the brochure's foreword, the company explains: "We at Lukens Steel, engaged 100 per cent in war work, are acutely conscious of the importance of salvage collection, because, on occasion, we have been forced to shut down steelmaking furnaces because of lack of iron and steel scrap."

Acting upon that consciousness, the company planned, launched, and led a Coatesville salvage collection drive that yielded 616,065 lb of iron and steel, 9410 lb of rubber, 3233 lb of other metal scrap, 44,688 lb of paper, 7365 lb of rags and an unlisted quantity of "miscellaneous." Population of Coatesville is about 14,500. All scrap metal, rubber, and rags were sold to local junk dealers. Paper was sold to nearby paper mills. Lukens Steel, itself, bought the scrap iron and steel, "thus insuring", the brochure explains, "the use of the metal in the production of steel for the Army, the Navy and the Maritime Commission."

Expenses of the campaign were defrayed by Lukens as a contribution to the war effort, and all proceeds were donated to the local chapter of the Red Cross. Income from the sale of salvage materials, however, could have covered all expenses.

Step by step, the brochure explains how the steel company enlisted the cooperation of Coatesville's public officials, its daily newspaper, such organizations as the Red Cross, the chamber of commerce and the council of defense, and finally of Coatesville's men, women, and children. The booklet—copies of which are available to business enterprises and to civic leaders—is generously illustrated and carries a chart of the campaign organization.

BOILER AND RADIATOR INDUSTRY SURVEYS PLANTS TO SPEED CONVERSION

DESIGNED TO speed the conversion of the plants of boiler and radiator manufacturers for the production of essential war materials, a survey of the manufacturing facilities of members of the Institute of Boiler and Radiator Manufacturers was completed recently.

Nearly 1500 copies of the survey, entitled Facilities for War Production, have been sent to the War Production Board, including district and local offices, other government agencies, and prime contractors.

The survey is the most comprehensive ever made of the manufacturing facilities of the boiler and radiator industry. Detailed information is set forth on the number of employees at each plant, total floor area, number of cupolas, capacity of cranes, types of molding, average and maximum weight of castings, the type of cleaning used for castings, and other facilities such as tool rooms and pattern shops.

Commenting on the conversion possibilities of the plants surveyed, the booklet says:

"The plants owned by the members of this industry are equipped primarily to manufacture cast iron boilers, radiators, convectors, and other cored castings. Many companies also have production facilities for steel boilers, cast iron and steel furnaces, industrial equipment, plumbing equipment, blast heaters, heat exchangers, and sheet metal products.

"Some of the war products made in these plants during recent months on prime contracts or subcontracts include a variety of large, medium, and small gray iron castings for machinery and machine tools and castings required by the branches of the Army, Navy, and Maritime Commission. Many companies have been using their machining facilities in various ways, such as for the machining of iron and steel castings, steel forgings, and steel plate, on a subcontract basis. Some have been making wood and metal pattern equipment and dies.

"The nature of these plants and the available personnel is such that conversion to the production of war materials may be accomplished quickly and at a much lower cost than would be involved in the building of new plants. Conversion to the making of steel, aluminum, and magnesium castings is a possibility which should not be overlooked by those who are responsible for obtaining expanded production of such castings.

"Considerable plant storage space is normally required for the products of this industry. This space is now available for other purposes, such as the installation of additional facilities, assembling work, etc.

"Many of the companies in the industry have arranged to supplement their own facilities with those of other plants in their vicinity and similar arrangements can, no doubt, be made as occasion demands.

"The production men in this industry are competent foundrymen and the nature of their work is such that considerable ingenuity is required for the successful operation of their plants. Each member of this industry has engineering and drafting personnel available for converting plants to war production.

"All of the companies in this group are well established, having been in business for a number of years. No manufacturer in this group normally does an annual volume of business less than $1,000,000 and in several cases the individual annual sales amount to many millions of dollars.

"The standing of these companies is such that little difficulty should be involved in arranging for financing of defense contracts where required. In most cases, this financing can be arranged by the individual manufacturer."

The booklet is illustrated with 26 pictures of manufacturing processes which are of the greatest interest to the WPB and prime contractors.

HELP PUT EMPTY CYLINDERS TO WORK

Production requirements today are such that there is an increased demand for oxygen and acetylene. This demand can be met if empty cylinders are returned promptly and if cylinder stocks in the hands of users of oxy-acetylene welding and cutting are maintained at a minimum.

Cylinders must be kept moving. They must not be permitted to stand idle, either full or empty. The cylinder supply, now the most important factor in the distribution of compressed oxygen and dissolved acetylene, is still deemed adequate to keep these gases continually and readily available to essential users if all will cooperate in speeding up turnover rates.

Also, refrain from ordering more oxygen or acetylene than is required for immediate needs. Many shops allot not more than three oxygen and three acetylene cylinders to every two welding or cutting outfits in active service. This plan permits a 50 per cent reserve.

This appeal is made just as much to small shops, using two or three cylinders a month, as it is to large plants using up to 100 or more cylinders a month. For every day a cylinder is empty and idle is a day lost out of its productive life regardless of the size of the shop.

SILICA GEL DEHYDRATORS SPEED SHELL LOADING

THE TIME gap between powder and ultimate shell loading at a southern ordnance plant has been reduced by several hours as the result of a recent installation of silica gel dehydrators. The shell loading plant consists of a variety of buildings housing three powder and shell production lines, powder drying houses, and storage and shipping buildings. Two production lines are equipped with dehydrating air conditioning units, and others will be changed over with later plant expansion.

Major equipment consists of two rotary dehydrators. Used in connection with these units are two four-compartment dryers. Powder for shell loading is placed on flat trays in the dryers and conditioned air is circulated over and around the trays from the dehydrator. A low humidity of 5 per cent or less, required for drying powder to a maximum efficiency, is consistently maintained.

HEATING LIMITATION ORDER L-79 EXPLAINED BY QUESTIONS AND ANSWERS

THE FOLLOWING explanations of general limitation order No. L-79 (heating and plumbing equipment) as amended on May 23, 1942, to relax some of the restrictions of the original order, were among those issued recently in question and answer form by the plumbing and heating branch of the War Production Board.

Are the following items restricted by the definitions of the order:

Q. Breeching, flue pipe, air ducts, and fittings? A. No.

Q. Steel pipe? A. No.

Q. Water tanks other than hot water storage tanks and range boilers? A. No.

Q. Salvaged or damaged new materials? A. Yes.

Q. Is a contractor construed to be an ultimate consumer? A. No.

Q. Is damaged or defective new equipment considered to be "used"? A. No. It is still new material.

Q. May the materials covered by the definitions be sold at public auction? A. Yes, if sold to a person other than an ultimate consumer.

Q. May a manufacturer sell new metal heating equipment, or both, to a wholesaler without an A-10 or better rating? A. Yes. He may sell without restriction to anyone except an ultimate consumer.

Q. May a wholesaler or jobber sell new metal heating equipment, or both, to a retailer without an A-10 or better rating? A. Yes, he may sell without restriction to anyone except an ultimate consumer.

Q. May a person replace an existing oil fired furnace or boiler, with a coal burning furnace or boiler, or add a separate unit under paragraph (b)(8)? A. No. This paragraph covers only parts for conversion.

Q. May new heating equipment be installed under paragraph (b)(6) without a rating if there is no such equipment available currently in the building? A. This exception applies only to cooking stoves, heating stoves, and water heaters, and is limited to a place of residence. The customer must sign the certificate specified in order L-79 as amended.

Q. Does L-79 restrict the sale of water pumps? A. Only the sale of circulating pumps, vacuum pumps, and condensation pumps for use in connection with heating systems is restricted.

Q. Is the sale of gas burning warm air furnaces restricted? A. No. Only coal or oil burning furnaces are restricted.

Q. Are unit heaters including gas unit heaters construed to be space heaters under the terms of the order? A. No.

Q. What is the correct definition of "space heaters" as used in order L-79? A. "Space heaters" as used in L-79 as amended, means any above the floor device, except unit heaters, using coal, oil or gas as fuel for the direct heating of the space in and adjacent to that in which the device is located, designed for use without heat distribution pipes or ducts as integral parts of such heating devices.

Q. Is the sale of coal burning boilers and coal burning furnaces restricted? A. Yes.

WARTIME CONSERVATION IN THE OFFICE

One way to help in the present war effort is by concentrating on the conservation of office supplies and equipment. Many familiar supplies used in everyday office operation are becoming increasingly scarce and costly. Many types of office machinery and equipment are not procurable, and at the same time, record work resulting from wartime production has increased in volume. These conditions stress the importance of eliminating all possible waste in the office.

The procedures employed by a number of companies to inaugurate or intensify existing waste reduction programs are outlined in a report recently issued by the Policyholders Service Bureau of the Metropolitan Life Insurance Co. The report is called Wartime Conservation in the Office, and is available to executives who address the bureau on their business stationery. Address: Policyholders Service Bureau, Metropolitan Life Insurance Co., 1 Madison Ave., New York City.

FLOW OF SOLIDS IN PIPING

In equation No. 6 of the article, Flow of Solids in Piping, on p. 424 of the July 1942 HPAC, the numeral 2 should be in the denominator of the equation, rather than in the numerator as was shown.

WAR DEPARTMENT BUILDING AIR CONDITIONED

The new War Department building will be completely air conditioned and will be controlled by pneumatic equipment. It is said to represent the largest single temperature control contract in history. The one-mile periphery of the building is made up of five sides, each one-fifth of a mile in length. Each section is built separately and occupied as soon as finished. Only one section of the building is shown in the photograph. . . . The air conditioning systems cool, circulate, and filter the air in the summer; and circulate and filter it in the heating months. Heat is supplied by window radiators circulating hot water. The temperature of the hot water is determined by the intensity of the sun. . . . Charles S. Leopold is the consulting engineer; Mehring and Hanson, and Baker Smith & Co., Inc., are the heating and ventilating contractors.

Photo courtesy Minneapolis-Honeywell

I'M HAVING TROUBLE WITH A TRANSFER HEATER

. . . . says a reader of HPAC. Samuel R. Lewis analyzes the problem and suggests the answer

SUMMARY—Heating systems involving the heating of the water which is circulated through the radiators by means of a transfer heater connected to a steam boiler are always interesting because of the almost endless variations possible. A reader of HPAC has submitted information on a job—a one story office—which hasn't worked properly, and asks for help in analyzing the difficulty and suggesting the correction. Samuel R. Lewis (consulting mechanical engineer, and a member of HPAC's board of consulting & contributing editors) comes to the rescue here. His comments apply not only to this specific job, but include a number of practical suggestions for all who design and install hot water heating systems of this type. . . . The sketches show the job as installed (which doesn't work right), and Mr. Lewis' suggestions for correcting the trouble

SYSTEMS of this type, involving a transfer heater for heating hot water by means of a steam boiler, always are interesting because of the almost endless variations in physical structure due to the flexibility of the heating medium.

The contractor in this case reports trouble. The boiler is of cast iron, with 10 sections assembled like slices of bread in a horizontal loaf. He wished to heat the offices of a factory, with direct radiators on the floor. The office floor is about 2 ft below the water line in the boiler. He installed a single pipe main, hot water system, with an adequate and properly vented expansion tank and an electric circulating pump. I can find no criticism of the amount of radiation, the pipe sizes, or the workmanship, except at the source of heat—the transfer heater. The people in the office building could not keep warm last winter and *they* found plenty to criticize.

The contractor had installed rather an unconventional transfer heater—apparently with intent to reduce cost, friction, and heat loss. He tapped the side of every section in the boiler and installed a 6 in. horizontal header, connecting ten 1 in. pipes between the boiler and this header. He connected a 3 in. return out of the bottom at one end of this header into the return main of the steam boiler. Then he filled the 6 in. header with ¾ in. outside diameter U tubes to the extent of a specified 34.7 sq ft of surface, and this meant very close spacing of the copper tubes inside the header.

There is 537 EDR of cast iron radiation, demanding about 80,500 Btu per hr. With a 20 deg drop, the amount of water circulated will be 80,500 ÷ 20 = 4025 lb or 483 gph. If the friction drop does not exceed the usual 6 ft allowance, the 1½ in. circulating pump is ample in capacity. The transfer heater is said to have two passes for the water through the tubes, and if there are 12 U bends the water velocity through the 4 sq in. total tube cross section will be about 39 linear fpm, which is conservative and which indicates that the trouble is not in the part of the device having to do with the inside of the tubes.

The transfer heater must transmit 80,500 Btu per hr from water leaving the steam boiler at about 200 F to heating system water leaving the transfer heater at about 180 F, and entering the latter at 160 F.

Ordinary design for transfer devices of this type is to allow 30 F drop between the temperature of the water leaving the steam boiler and that returning to it. In this case so great a temperature drop is impracticable because due to the type of transfer heater, water returning to it at 160 F cannot receive enough heat from water leaving the transfer heater at 170 F to be of acceptable service. If the temperature drop on the steam boiler water is reduced from 30 to 10 deg, however, the situation improves.

80,500 Btu per hr ÷ 10 deg = 8050 lb or 966 gph to be circulated, and the following figures apply:

Boiler water inlet to the heater	200 F
Radiator water exit from the heater	180 F
Difference	20 F
Boiler water exit from the heater	190 F
Radiator water inlet from the heater	160 F
Difference	30 F

This gives a mean temperature difference of about 25 F, which would apply if the heater were a true counterflow device. However, it is not a true counterflow device, and 24 deg mean temperature difference is all that may be expected. With low water velocity on both sides of a copper tube the transfer

The Question—

THE EDITOR—

I will appreciate your assistance and advice on a job which is giving trouble, as the space is not heated satisfactorily. The building is a one story office and is heated with hot water by means of a converter attached to a steam boiler below the water line.

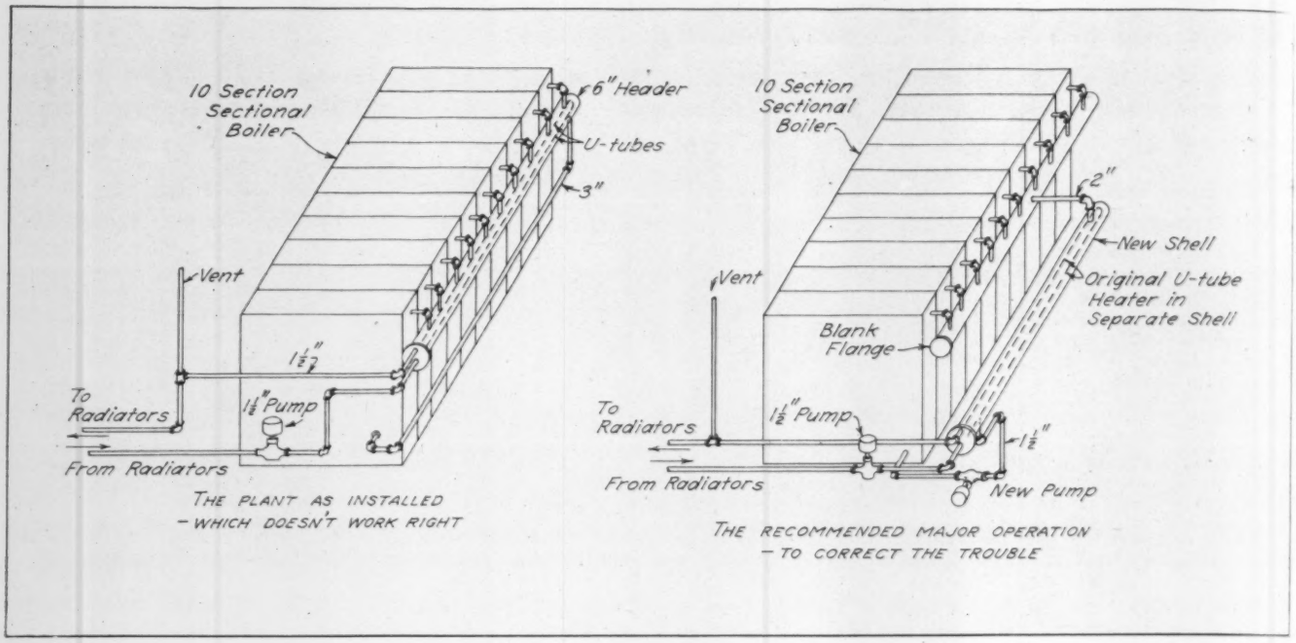
Radiation is based on a heat emission of 150 Btu per sq ft per hr with a temperature drop of 20 deg, which totals 537 sq ft.

The system is one pipe, forced circulation, using venturi fittings. The mains are carried beneath the floor in foundation space and the owner insists upon leaving the pipes uncovered, although the floors and ceilings were considered in computing heat loss.

The circulator is a 1½ in. horizontal standard make with a delivery of 15 gpm against a head of 6 ft of water.

The converter as furnished by the manufacturer has 34.7 sq ft of ¾ in. OD copper U tubes in a 6 in. inside diameter shell 7 ft long from the flange of the expanded plate to the end of shell. Massing of these tubes with only one spacer plate at the ends of the tubes causes them to touch metal to metal nearly the entire length. Circulation through the converter is dependent upon gravity. Converter is a two pass type.

What space between tubes is necessary to provide the required velocity? What should be pressure drop through the tubes, and what should the temperature be of the outlet and inlet of the heating water with boiler water at 200 deg? Boiler is automatically fired with oil. Office and shop are thermostatically controlled. Maximum boiler pressure is 5 psi.—P. D. B.



rate can be expected to be not over 100 Btu per sq ft per hr per deg difference.

Suppose the copper tubes are credited with 100 Btu per sq ft per deg difference and that we assume 24 deg temperature difference. Then 100 Btu per hr × 34.7 sq ft × 24 = 83,280 Btu per hr, compared with the 80,500 Btu per hr desired. It appears reasonable to believe, therefore, that the 34.7 sq ft of copper surface will be adequate if the boiler water is forced to flow with reasonable uniformity over all of the copper tube surface.

How to Fix

The conventional and well proved method of connecting a transfer heater to a steam boiler is to run, say, a 2 in. pipe from the header of the ten 1 in. pipes, to a transfer heater having larger diameter with shorter tubes than those which were installed, so that the flow of hot water from the boiler would meet with less obstruction by the tubes.

It seems clear to a diagnostician 1000 miles distant from the plant that a major operation is indicated. It is clear enough that, as installed, some of the water from the boiler flows sluggishly through a few of the ten 1 in. pipes connected to the header near the end which has the 3 in. return to the boiler, but that most of the 1 in. pipes from the steam boiler to the header are loafing on the job.

I would remove from the 6 in. header the copper U tubes, installing them in, say, an 8 in. pipe. I would connect from about the middle of the 6 in. header a pipe about 2 in. in diameter into the top of the 8 in. new shell at one end and would connect the 3 in. return to the steam boiler from the bottom of the end of the 8 in. shell most remote from the 2 in. connection. I would install an additional 1½ in. circulating pump similar to the present one on the direct radiation so as to insure adequate transfer of heat from the water of the steam boiler to the water of the radiator system. This pump might respond to an aquastat in the 3 in. pipe or even to an aquastat in the return water from the heating system. This pump ought to circulate about 1000 gph against a friction head of, say, 3 ft.

MEASUREMENT OF WATER VAPOR AND GASES

For their technical paper presented at the 1941 annual meeting of the American Society for Testing Materials describing in detail extensive studies on the measurement of water vapor and gases, F. C. Todd, assistant professor, petroleum and natural gas engineering, and A. W. Gauger, director, mineral industries research, both of Pennsylvania State College, have received the Charles B. Dudley medal.

The paper describes the authors' extended work in developing a precise laboratory method and a field method for estimating moisture in fuel gases. The investigation involved the building of special equipment and carrying out of numerous research investigations. Moisture content of fuel gases is extremely important in production, transportation, and distribution, since control of corrosion, prevention of ice formation and other factors depend on the amount of moisture.

The laboratory method they developed depends on the absorption of light by water vapor at a particular wave length in the near infrared. This involved the building of sensitive equipment to make the various measurements. The field method is based on the change of color of the chemical cobaltous bromide in an organic solvent on the addition of water.

According to newspaper reports published last month, an employee of one of the large plants engaged in war production died while at work during a middle-western heat wave and his death was attributed by the sheriff's office to the heat. Afternoon temperatures as reported by the weather bureau were in the 90's during the heat wave.

ALLOCATION CLASSIFICATION SYSTEM

IT BECAME mandatory on July 1 for the new allocation classification symbols to be used on all orders placed by manufacturers, fabricators, primary producers, etc. The allocation classification system has been designed to enable the War Production Board to trace the flow of materials in terms of end use, from primary producers to finished products.

Complete information about allocation classifications is given in a booklet on priorities regulation No. 10 and the allocation classification system, issued by WPB's division of industry operation. The following information is based on this booklet, which booklet should of course be referred to for complete information.

Where the business of a purchaser does not fall directly into any of the classifications, the purchaser has no symbol to identify its own business but simply transmits the symbols it receives on purchase orders which its customers have placed with it. For example, the manufacturer of electric motors receiving an order from a railroad bearing the symbol 10.10, places the same symbol 10.10 on its purchase order.

In addition to the numerical symbols, a series of letter symbols has been adopted to indicate the purchaser, as follows:

Army	USA
Navy (includes Maritime Commission)	USN
Lend-Lease	LL
Other foreign purchasers	FP
Domestic purchasers	DP

The appropriate purchaser's symbol should in each case precede the numerical allocation symbol.

Following is the list of numerical allocation classification symbols. The symbol numbers have no relation in order of importance:

Allocation Symbol	MILITARY
	Class 1.00 Aircraft—Production and Maintenance (complete except for armament and ammunition—as approved by the Joint Aircraft Committee).
	Class 2.00 Ships, Production and Maintenance (complete except for armament and ammunition).
2.10	Battleships.
2.20	Aircraft carriers.
2.31	Escort vessels (aircraft), combat, loaded transports, and combat loaded cargo ships.
2.32	Patrol vessels.
2.33	Landing craft including the following types: APM, ATL, YTL, tank lighters, artillery lighters, landing boats, support landing boats.

2.40 Light cruisers.
2.50 Destroyers including escort vessels.
2.60 Submarines.
2.70 All other types of naval craft.
2.80 Repairs to all naval vessels.
2.90 Ships for Maritime Commission.

Class 3.00 Vehicles—Production and Maintenance (complete except for armament and ammunition).
3.10 Tanks and armored vehicles—all types.
3.20 Vehicles, except rail—all other military types.

Class 4.00 Armament and Weapons—Production and Maintenance (complete mounts and related equipment).
4.10 Aircraft.
4.20 Anti-aircraft, barrage balloon equipment, A. A. searchlights.
4.30 Artillery including railway and seacoast.
4.40 Fire control, all types.
4.50 Machine guns—ground, hand arms.
4.60 Naval, all types.
4.70 Tanks and anti-tank.
4.90 Weapons of all other types.

Class 5.00 Ammunition—Production and Maintenance (complete items).
5.10 Ammunition 20 mm. and above.
5.20 Ammunition, small arms below 20 mm.
5.30 Bombs, depth charges, mines and torpedoes.
5.40 Propellants, chemicals, explosives.
5.50 Pyrotechnics.

Class 6.00 War Equipment and Supplies—Production and Maintenance (complete with related equipment).
6.10 Chemical warfare equipment and supplies.
6.20 Clothing, general supplies and subsistence.
6.30 Mapping, map reproduction and photographic equipment.
6.40 Medical equipment and supplies.
6.50 Military field construction equipment.
6.60 Military radio and wire communications, and Radar or electronic equipment—all types.
6.70 Military railway including rail vehicles and bridge equipment.
6.80 Supplies and equipment—all other military types.
6.90 Supplies and equipment—all other.

Class 7.00 War Facilities—Construction and/or Maintenance.
7.10 Air fields, bases, camps, coast defense, depots, forts, navy yards, posts, stations—continental U. S. A.
7.20 Air fields, bases, camps, coast defense, depots, forts, navy yards, posts, stations—outside continental U. S. A.
7.30 Munitions manufacturing facilities and proving grounds—Government owned.
7.40 Panama Canal.
7.50 Shipyards and ship repair facilities—Government owned.

INDUSTRIAL AND CIVILIAN

Class 8.00 Raw Materials, Production and Processing of.
8.10 All metals, production (including mining) smelting and processing of.
8.20 All chemicals, production and processing of.
8.90 All other raw materials, production and processing of.

Class 9.00 Power, Light, and Heat.
9.10 Electricity.
9.20 Petroleum.
9.30 Coal and coke.
9.40 Gas.

Class 10.00 Transportation.
10.10 Railroad including urban and interurban.
10.20 Automotive.
10.30 Roads, streets, etc., construction and maintenance of.
10.40 Water transportation, including construction of privately owned shipyards.
10.50 Air transportation.
10.90 All other transportation.

Class 11.00 Communication.
11.10 Telephone.
11.20 Radio.
11.30 Telegraph.
11.90 All other communication.

Class 12.00 Health and Safety (Governmental and Private).
12.10 Sanitary and health systems and facilities.
12.20 Health equipment and supplies including personal care.
12.30 Safety equipment and supplies.

13.00 **Class 13.00 Agricultural Equipment and Supplies.**

14.00 **Class 14.00 Industrial Food Processing.**

15.00 **Class 15.00 Wearing Apparel.**

16.00 **Class 16.00 Equipment and Supplies for Household Use.**

Class 17.00 Education and Information.
17.10 Printing and publishing.
17.20 Education.

18.00 **Class 18.00 Recreation and Amusement.**

19.00 **Class 19.00 Equipment and Supplies for Office Use.**

Class 20.00 Machinery and Equipment for Industrial Use.
20.10 Metalworking machinery.
20.20 All other—including mine, construction, special and general industrial.

Class 21.00 New Buildings, Construction Of.
21.10 Buildings for manufacturing and commercial purposes, construction of.
21.20 All types of dwellings, construction of.
21.90 All other types of buildings, construction of.

22.00 **Class 22.00 Operating Supplies and Building Repair and Maintenance.**

23.00 **Class 23.00 All Other End Uses** (excludes all subassemblies and parts going into finished products coming with the other classes).

Radiography Symposium Features ASTM Meeting

THAT THERE has been little diminution in standardization and research work in engineering materials as carried out by the American Society for Testing Materials was evident from the heavy registration of members, committee members and guests at the 45th annual meeting held at Atlantic City, June 22-26, the total figure reaching 1376—which does not include more than 200 ladies and others of the members' families. While this did not quite reach the Atlantic City figure of 1441 at the 1940 annual meeting and is below the figure for Chicago last year, it is an excellent attendance record, considering present conditions.

An outstanding feature of the meeting was the symposium on radiography, comprising 13 technical papers presented in three sessions. Arranged by committee E-7 on radiographic testing, headed by H. H. Lester of Watertown Arsenal, the symposium when published will acquaint the engineering profession with the most recent developments in x ray and radium radiography of engineering materials. Since 1936, when the society held its first symposium on this subject, there have been phenomenal increases in applied voltage, more extended use of radium, and a much wider diversification of products investigated by these testing methods.

In the discussion of radiography of welds and weldments, it was indicated that much of the present production speed has resulted from welding, which in turn has greatly increased the number of radiographic testing units in use not only in the pressure vessel field but for spot checks in other structural welds. Similarly, the field of gamma ray radiography is expanding. Also explained were some of the advantages of the million volt x ray unit.

There was discussion of gamma ray radiography of welded high pressure power plant piping, with some excellent illustrations of results achieved and successful technical methods that have been employed.

Messrs. Schier and Doan of Lehigh University reported on studies involving precision radiography in which an equation had been developed giving the minimum radiography required for adequate definition of the penetrameter required in the ASME boiler code. Another paper by the same authors described equivalent penetrameters in radiographic testing.

Steel and Iron

Notable in the session devoted to steel was the report of committee A-1, presented by Norman L. Mochel, chairman. Many important recommendations were acted on as recommended by the committee. Particularly important were those in the field of pipe and tubing, where a new method of determining elongation values based on pipe wall thickness is being established in two of the country's most basic specifications for welded and seamless steel pipe (A53) and for lap welded and seamless steel pipe for high temperature service (A106). Also incorporated in these standards is a new method of determining flattening test requirements by means of a formula which establishes more rational values based on pipe sizes and grades. These two specifications will also permit the use of acid bessemer seamless material and the electric resistance welding process.

Two new pipe specifications were approved at the annual meeting, one covering copper brazed tubing suitable for general engineering uses, particularly in the automotive, refrigerator and stove industries for fuel lines, oil lines and so forth. The second specification covers welded alloy open hearth iron pipe which is made from a highly refined iron produced in the basic open hearth or electric furnace with which is alloyed in a solid solution a minimum of 0.40 per cent copper and 0.05 per cent molybdenum.

The 14th session of the meeting included several technical papers and reports on the subject of iron. Committee A-7 on malleable iron castings has virtually completed specifications for this material applicable for flanges, pipe fittings, and valve parts, but although approved in the committee, some further consideration and study will be made before they are officially referred to the society. In a paper covering creep studies on cupola malleable iron, it was indicated that the material made a very creditable showing in the light of accepted values for silicon killed carbon steel, having two-thirds creep strength at 800 F. Excellent stability was indicated in the test, little effect being shown until temperatures of 900 F were reached and then with only slight growth. The allowable working stress for malleable iron, based upon creep studies using an established policy of determining design stress, justifies 5600 psi up to 775 F, a value several times that used in current designs limited to 450 F maximum service temperature.

Two proposed standards have been developed by committee A-3 on cast iron, one covering compression testing of cast iron and another a recommended practice of making torsion tests on cast iron. The compression test was approved at the meeting subject to confirming letter ballot in the committee, but the torsion test will be submitted to the society in the summer after it has been considered a bit further by the committee. Revised definitions of terms relating to cast iron were approved, as were editorial modifications in the procedure for evaluating the microstructure of graphite in gray iron (A247-41T).

Coal and Coke

In addition to a report of committee D-5 on coal and coke summarizing the current status of its research and standardization work, two technical papers in this field were presented at the meeting, one dealing with a statistical study of the precision of methods for analysis of coal and coke which gave some results of a study of over 32,000 analyses involved in 176 sets of determinations.

The Fight for the Ceiling

MAYBE IT'S NOT really a "fight", but the air conditioning engineer, the lighting engineer and the acoustical engineer each must claim a certain proportion of the ceiling area for his equipment. It is therefore essential that the interests of all three be coordinated in order that the best overall design may result. The purpose here is to discuss briefly the various factors involved. . . . The author, Knight C. Porter, is supervisor of the air conditioning division of Commonwealth Edison Co.

INTERNAL HEAT of an air conditioned space is absorbed by introducing air at a temperature below room temperature. Air is the cooling medium, and it requires 160 cfm to handle 1 kw of lighting load, assuming a 20 F temperature difference between the entering air and the room.

Let us consider the sensible heat load analysis for a busy general office space where there are 50 sq ft per person and totally indirect light of 25 foot candles provided by 500 watt fixtures on 10 ft centers, using typical values for an intervening floor. The lighting load of 5 watts per sq ft would probably represent 50 per cent of the total sensible heat gain.

Multiplying 5/1000 kw by 160 cfm, we get 0.8 cfm, or 48 cfh of air per sq ft of floor to handle the lighting load. As this is half the total sensible load, 96 cfh would be required. Therefore, with a 10 ft ceiling we would need 9.6 air changes per hour. Air changes per hour have long been used as an index of room air motion and therefore "draft." Although this index is far from exact because of the wide differences in the methods and devices of air supply and return, air changes in excess of 12 per hour may be expected to give draft objection.

Therefore, in our example (5 watts per sq ft) requiring 9.6 air changes, we are in a safe range of air motion. If the other sources of heat gain remain the same, but the lighting is increased to 7½ watts per sq ft, our air change index becomes 12 per hour. Thus, in the air conditioned office space with a ceiling height of 10 ft, 7½ watts per sq ft lighting load represents a critical level insofar as air motion is concerned.

Let us see what lighting intensities were available with 7½ watts per sq ft in incandescent light:

Type of Light	Foot Candles per Watt per Sq Ft	Foot Candles
Direct	7.5	56.25
Indirect	5.0	37.5

Depending on the character of light desired, I have been assured that something between 75 and 100 foot candles are available using fluorescent lighting equipment with the same load we have been talking of for incandescent; i.e., 5 watts per sq ft.

The settlement of the disputes between the lighting man (who was in search of 50 to 75 foot candles) and the air conditioning man (who just could not handle 10 to 15 watts per sq ft) has been accomplished. In this case the air conditioning man "let George do it."

Insofar as air conditioning is concerned there are two interesting characteristics of fluorescent lighting. They are the coolness of light, and the effect of surrounding temperature on the light output.

There has been considerable misunderstanding concerning the coolness of fluorescent light. In the first place, we must recognize that every connected watt of electricity in the occupied space contributes 3.4 Btu per hr whether it is used in incandescent lighting, fluorescent lighting, business machines, or what not.

Doubtless the idea that a fluorescent lamp is so cool that it should be disregarded as a source of internal heat has been due to a considerable fanfare concerning the low radiant heat of the tube as compared with the incandescent lamp. Much has been made of the fact that the radiant heat output of the fluorescent lamp represents only 34 per cent, whereas that of the incandescent lamp is 85 per cent, of its total energy. Therefore, since the light output of the fluorescent is double that of incandescent, the radiant heat per unit of light is only one-fourth as great as that of the incandescent source. Granting that this be true, it seems to me that this should be put down as an interesting phenomenon—but should not be implied as having any air conditioning or comfort reaction. Dr. Matthew Luckiesh has shown that the threshold of radiant temperature response of the forehead occurs at about 125 foot candles of incandescent illumination.

Howard Sharp, in a paper presented before the Illuminating Engi-

neering Society on Radiant Temperatures from Lighting Systems with Comfort Correlations, stated:

It can safely be concluded that more stress has been placed upon lighting as an unfavorable factor in comfort than is justified by present knowledge. In fact, it might be said that the radiant heat from lighting systems now in use and likely to be used for some time to come has no effect whatsoever on comfort.

It is the author's observation that appraisal of comfort by an individual is a complex process in which psychology plays a large part, whereby sensations arising from an unobvious, unfavorable environment are likely to be attributed to some more visible, and, hence, obvious factor. Lighting is almost always the recipient of this antagonism.

This seems to support the statement that the sensation of heat is a "psycho-physiological complexity," as Dr. Luckiesh has called it. It should also tend to disprove the idea that radiant heat from incandescent light was the thing which made office air conditioning desirable—and that the use of fluorescent light is almost equivalent to buying a cooling system.

The fluorescent lamp operates at its maximum efficiency at normal room temperatures of 70 to 80 F where the temperature of the glass tube itself has a value of 100 to 120 F. At too low temperature the mercury condenses out and the activating ultraviolet radiation is reduced. Draft or high velocity air motion across the lamp also causes a loss of efficiency. If the lamp is exposed to cold air supply at 60 F it could be expected to operate at above 95 per cent efficiency if enclosed, and at 80 per cent efficiency if exposed. Therefore, in addition to the improved character of light when diffusing glass cover plates are used, we can expect the higher operating efficiency of the enclosed lamps to compensate in part for the light absorption of the cover plate where the fixtures must be in the path of the cold air supply.

Because of the relatively low watts density of the fluorescent lamp (using only 10 watts per lineal foot) it has presented what we might call a bulky source. In normal procedure something between 10 and 30 per cent of the ceiling area will be devoted to lighting equipment, depending upon the light intensity desired. For this reason we can see how the area for acoustic treatment is curtailed, and, therefore, why we should take a brief look at this problem.

Acoustic treatment may be divided into three classifications: (1) Noise quieting. (2) Acoustic correction (auditoriums). (3) Sound insulation (quieting noises transmitted from one room to the next).

In office treatment we are largely concerned with only the first classification—noise quieting or sound absorption. The very elements which have made office procedure efficient have added to the distraction of the office worker. The telephone bells, signal buzzers, typewriters and business machines have added their small contribution to internal office noise. The addition of trucks and autos to street car clatter has produced traffic noise of real proportions. Even the automatic traffic light has been unable to quiet the traffic whistle.

Year around air conditioning has fortunately allowed us to isolate the office worker from a large portion of street noises. It has, however, left us with internal noises. In part, therefore, air conditioning has tended to focus attention upon the problem of absorption of internal noise.

The coordination of air conditioning, acoustical treatment and fluorescent lighting thus is a problem of apportioning a fair part of the ceiling to each claimant.

The air conditioning engineer needs some part of the ceiling, particularly in the general office. Because the office worker has limited physical activity and no facility to move his work to a more comfortable spot, he is unusually difficult to please. An air movement which would be entirely satisfactory in a restaurant becomes an insufferable draft in an office. Because of this, air diffusing outlets for ceiling location have been widely used in offices. In order that the air conditioning man can obtain overhead outlets, he, of course, must also have overhead supply ducts. If the ducts must be exposed he will need approximately 15 per cent of the ceiling area; if recessed, his needs can be satisfied with outlet area only, or 1 per cent.

The lighting man requires somewhere between 15 and 30 per cent or more of the ceiling with fluorescent lighting, depending upon the lighting intensities desired.

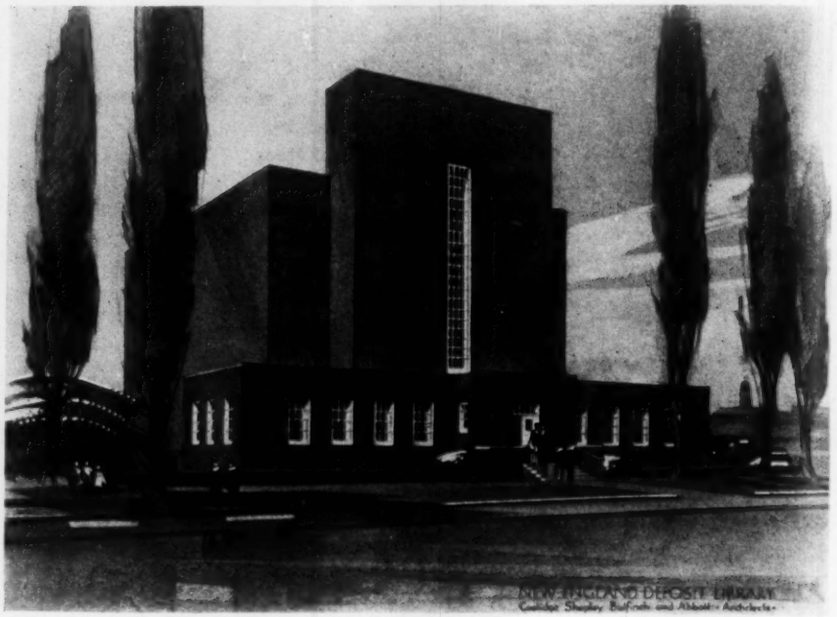
Then, if the acoustic treatment can be applied to only 70 per cent of the ceiling, we may still have a noise absorption factor of almost 75 per cent if we use an 85 per cent absorption material, according to acoustical engineers' data. If as much as 50 per cent of the ceiling were devoted to lighting and air conditioning, it would still be possible to obtain 65 per cent noise absorption with an 85 per cent material.

Engineers and draftsmen at a large war production works go about their jobs under nearly one-third of a mile of fluorescent lamps

New England Deposit Library Provides Storage for "Dead" Books

By G. K. Saurwein

SUMMARY—In order to extend library facilities for active material, a cooperative storage library for "dead" or little-used books has been built. Of fireproof and windowless construction, except for a small reading room and workroom, it is heated by an oil fired boiler to a temperature of 50 F by means of a duct system. The boiler setting was arranged to permit burning coal on grates at the front end. . . . The workroom and reading room will be heated to normal room temperatures by means of standing radiation. . . . The author was formerly superintendent of the engineering division of the Harvard department of buildings and grounds and is now a major in the ordnance department, U. S. Army



As long ago as 1902, President Eliot of Harvard University proposed that there be established a storage building for books seldom called for, in order to make room for the increasing influx of active library material. He termed it a library for "dead books." That term irritated some of the faculty members who felt sure that professors did not collect "dead books," and thus the idea was not carried out at that time.

However, of the making of books there has been no end—the demand for library space has continued at an ever increasing rate. And when about three years ago K. D. Metcalf, the director of the university libraries, began to make plans for extending library facilities, the idea of a storage library was raised again. This time the idea of a cooperative venture in book storage developed; that is, a place where all the libraries in the metropolitan area might store their little-used books.

The idea found ready acceptance with the other libraries in the area, and soon steps were taken to get the project under way. Since the state library and other public libraries were to participate in the venture it was thought wise to have an enabling act passed by the legislature. When this act was passed and duly signed, the libraries concerned incorporated for the purpose of establishing the New England Deposit Library to house their "dead" books.

Harvard has provided the site and the funds for the new building, a fireproof, windowless, warehouse type with a small workroom and a reading room on the front, the latter rooms having windows. The site permits extensive additions as the demand for space increases.

Since this project is some distance from the university steam mains, the building has its own heating plant. A welded steel fire tube boiler, built for 15 psi pressure, is fired with heavy oil from the rear. In view of the possibility of oil shortage, the setting has been arranged so that coal may be burned on grates at the front end. There are the usual safety appliances to conform with statutory requirements.

The heating and ventilating equipment will be operated as a vacuum system with steam supplied at 2 to 5 psi pressure. The equipment will be fully automatic and will require only supervisory attention.

The workroom and reading room will be heated with standing radiators to normal room temperature. The main part of the building—the book stacks—will be heated with warm air. The outside air inlet, warm air supply and return ducts, are housed in the tower at the front of the building, together with book lift, stairways, and service closets.

The supply duct riser has branches run out at each of six floors, with adjustable registers at alternate aisles. The branch ducts at the top floor have a booster coil to take care of the roof heat loss. The return air is drawn through registers at the front of each floor. It is planned to heat the book storage space to only 50 F. During heating weather the air will be largely recirculated.

Make up air, with inlet at the top of the building, is cleaned by a constant pressure drop, viscous surface, air filter of the rotating curtain type. The air will be humidified by misting nozzles during the heating season.

Mechanical cooling equipment will not be installed. Considerable cooling may be accomplished in this region by running the fans at night with 100 per cent make up and then setting the dampers for 100 per cent recirculation during the day. Should further cooling be desirable it can readily be provided later by means of ground water, of which there is an abundance at the site.

This project was carried out under the direction of the business manager's office of the university. Coolidge, Shepley, Bulfinch and Abbott, architects for the university, made the plans. The George A. Fuller Co. was the contractor. Buerkel and Co., engineers and contractors, made the heating plans.

FAN LAWS --Their Derivation and Use

Thorough Understanding of Fan Laws of Great Value to Users, Permits Selection for Efficient Operation . . . By William Goodman

SUMMARY—**A thorough understanding of the fan laws can be of great value to the user of fans. The fan laws can be of help in selecting fans so that they operate at their most efficient point and in determining the effect of changes in fan speed. Important in many cases is the effect of changes in the density of the air that the fan is handling. All fans are rated in terms of standard air, the density of which is 0.075 lb per cu ft. . . . . Although the effect on fan performance with changes in air density can frequently be neglected, there are many cases where these effects should be taken into account. It has been the author's experience that the fan laws dealing with changes in density are particularly likely to be misapplied. In the article of which this is the first part, a clear explanation is given of the proper application of the fan laws and their use is illustrated with examples. . . . . Mr. Goodman is consulting engineer, The Trane Co., and a member of HPAC's board of consulting & contributing editors.**

SO-CALLED "LAWS" relating the various performance characteristics of fans—such as air delivery, static pressure, and horsepower — have been used for many years in fan computations. For example, such laws are used to compute the air delivery and horsepower of a fan when it runs at a speed different from the speed at which the air delivery and horsepower are known. Also, the laws dealing with the performance of fans when handling air at various densities are of great utility to the user of fans in his daily work if they are well understood and properly applied. Although the application of some of the fan laws is well understood, there are other fan laws of equal utility and value whose use is not so well understood and which, in the author's experience, are frequently misapplied. This is particularly true of the relationships dealing with changes in air density.

It is the purpose of this article to review the various relationships which are grouped under the name of "fan laws" and to explain their correct use. In addition, although the fan laws are published in a number of various text books, the author has never yet seen a complete derivation of these various laws. Therefore, because they are interesting and because they can be of value to the user, this article will also give the derivations of the various fan laws.

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Similar Fans

All of the fan laws apply only to geometrically similar fans. Two fans are geometrically similar if they are alike in all proportions and in all details regardless of their size. If a photograph were taken of the smaller of two similar fans and the photograph enlarged, it would then be an exact picture of the larger fan. This means that all blade angles and the number of blades remain the same, but the diameter, width, and all dimensions are multiplied by the same factor in determining the dimensions of the larger fan from those of the smaller fan. The fan laws do *not* apply unless the fans are geometrically similar.

When a fan is tested, the quantity of air delivered against various pressures is measured while the fan is running at constant speed. A performance curve which shows the cfm delivered against the various pressures—static or total—is then drawn. Such a performance curve is illustrated in Fig. 1. In addition, the efficiency of the fan is also determined during the test and plotted against the quantity of air delivered. The efficiency and performance curves plotted in this way apply only to the one fan tested and at the one speed at which the fan was tested. They also apply only when the fan is handling air of the one density available during the test.

Corresponding Points

To determine the performance of an entire series of similar fans of different sizes and different speeds, it is desirable to plot the test data in a general manner so that they can readily be used for computations involving geometrically similar fans of any size and running at any speed. One method of plotting general performance curves from test data is illustrated in Fig. 2, in which the velocity ratio is plotted against

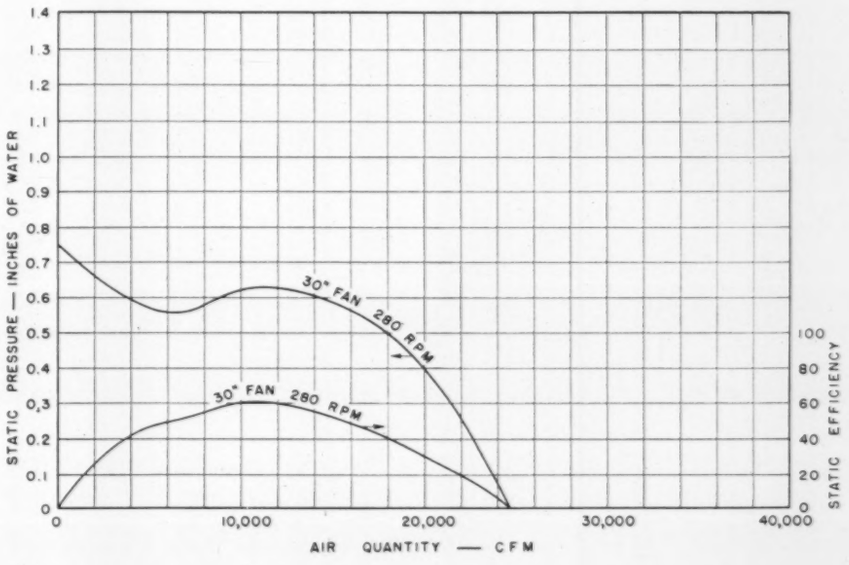


Fig. 1—Typical fan performance and efficiency curves obtained by test

the pressure ratio. These ratios are defined as follows:

$$R_u = \frac{U_o}{U_p} \quad \text{.....[1]}$$

$$R_p = \frac{p_s}{p_t} \quad \text{.....[2]}$$

If the air quantity and static pressure are known, the speed and horsepower of a given size fan can be computed directly from the data in Fig. 2.

The ratio curve of Fig. 2 also has the very important property of being independent of the air density. It can be used to determine the fan characteristics and fan performance when handling air of any density. For the present, the discussion will be confined entirely to air of standard density. The changes in fan performance with changes in air density will be discussed in detail later.

The generalized performance curves for a series of geometrically similar fans illustrated in Fig 2 are presented here because they are of value in defining an important concept upon which all of the fan laws are based. This is the concept of *corresponding points.*

If several different performance curves like the one illustrated in Fig. 1 are plotted for different size fans running at different speeds, the points on these performance curves at which *the velocity and pressure ratios are the same* may (for want of a better name) be called *corresponding points.* From Fig. 2 it is apparent that if two fans are operating at the same pressure ratio (that is, at corresponding points) the efficiency of the two fans will be exactly the same. Consequently, it is apparent that all geometrically similar fans—regardless of their size or speed—have the same efficiency when operating at corresponding points on their performance curves.

Symbols

A_o = outlet area of fan, sq ft;
D = diameter of fan wheel, in.;
d = density of air, lb per cu ft;
d_w = density of water, lb per cu ft;
E = efficiency of fan, either static or total;
h = head, ft of air;
(hp) = horsepower;
N = fan speed, rpm;
p = pressure, in. of water;
p_s = static pressure, in. of water;
p_t = total pressure, in. of water;
R_p = pressure ratio (see equation 2);
R_u = velocity ratio (see equation 1);
U = velocity, fpm;
U_o = outlet velocity of fan, fpm;
U_p = peripheral velocity or tip speed, fpm;
V = volume of air per unit of time, cfm;
W = total weight of air delivered, lb per min

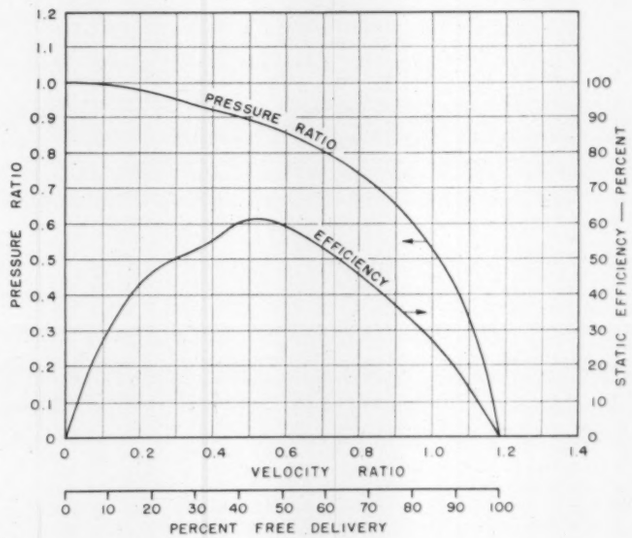


Fig. 2—Ratio and efficiency curves which can be plotted from test curves such as the one in Fig. 1. The ratio curve in this figure is applicable to a complete line of geometrically similar fans of any size and running at any speed. Furthermore, this ratio curve is applicable to air at any density; its use is not restricted to air of standard density.

However, it is also apparent from Fig. 2 that points having the same efficiencies are not necessarily corresponding points, because two different points on the ratio curve may have the same efficiency. In other words, at all corresponding points the efficiency is the same, but points at which the efficiencies are the same are not necessarily corresponding points.

All of the fan laws are applicable only to the corresponding points of geometrically similar fans. In other words, if the cfm is known when a fan is running against a given speed, the cfm delivered when the fan is running at a different speed can be determined from the fan laws. However, at both speeds, the fan must be operating at corresponding points on the performance curves for the two speeds—that is, the pressure and velocity ratios, and the efficiencies, must be exactly the same.

At any given speed, the fan delivers the maximum amount of air when the static pressure is zero; that is, when the fan is discharging freely into the atmosphere. This maximum air quantity at zero static pressure is called the *free delivery cfm.* Thus, for the fan of Fig. 1 the free delivery cfm is 24,700 cfm.

For any given rotative speed, tip speed of a given fan is constant. Inasmuch as the constant tip speed is the denominator of the velocity ratio of equation 1, it is evident that the velocity ratio varies directly with the outlet velocity. The air delivered by any given fan varies, of course, with the outlet velocity. Consequently a scale showing the per cent of free delivery may be added along the base of the ratio chart as in Fig. 2. For any given point on the ratio curve, this percentage scale shows the percentage of the free delivery cfm that the fan can deliver. This percentage scale provides a valuable check when making arithmetical computations by means of the various fan laws. Regardless of how the speed or fan diameter is varied, for any two corresponding points the *per cent of free delivery* is the same.

The efficiency curve can be transferred from Fig. 1 to Fig. 2 by means of the free delivery percentage. For the same per cent of free delivery, the efficiency will be constant. Thus, by computing the percentage of free delivery cfm for the air quantities in Fig. 1, the static efficiency can be plotted in Fig. 2 for these same percentages.

Variations in Air Quantity

Two of the most widely used fan laws are

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} \quad \text{.....[3]}$$

and

$$\frac{V_2}{V_1} = \left(\frac{D_2}{D_1}\right)^3 \quad \text{.....[4]}$$

To derive these two fan laws, the velocity ratio, (U_o/U_p), may be written

$$\frac{U_o}{U_p} = \frac{V}{A_o}\frac{1}{U_p} \quad \text{.....[5]}$$

However,

$$U_p = \pi ND \quad \text{.....[6]}$$

Also, it is apparent that for geometrically similar fans, the length and width of the fan outlet each vary directly with the diameter of the fan wheel. Consequently,

$$A_o = kD^2 \quad \text{.....[7]}$$

where k is a constant for a complete line of geometrically similar fans. Substituting [6] and [7] into [5],

$$\frac{U_o}{U_p} = \frac{V}{\pi kND^3} \quad \text{.....[8]}$$

For two different sized fans operating at different speeds but at corresponding points [that is, for both fans (U_o/U_p) is the same] it is obvious from equation 8 that

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}\left(\frac{D_2}{D_1}\right)^3 \quad \text{.....[9]}$$

This is the fundamental equation from which the two basic fan laws expressed by equations 3 and 4 are derived. For the same size fan, $D_1 = D_2$. Hence, equation 9 reduces to equation 3. On the other hand, if two different sized similar fans are run at the same speed, $N_1 = N_2$, and equation 9 reduces to equation 4.

Variations in Pressure

If the air quantity that a fan will deliver is computed by means of either equation 3 or 4, the pressure —either static or total—against which this new air quantity will be delivered will be different from the pressure against which the original air quantity was delivered. When various air quantities are computed by equations 3 and 4, the velocity ratio (that is, the ratio of the outlet velocity to the tip speed) will always remain constant. Therefore, it is evident from Fig. 2 that the pressure ratio must also remain constant. Hence, if either the rpm or the diameter are increased, the pressure against which the fan will deliver the increased volume will also increase.

In any centrifugal pumping device, the head varies as the square of the tip speed. For a proof of this, see Dodge and Thompson [Fluid Mechanics, p. 123; published by McGraw-Hill Book Co.]. Hence, for any one point on the ratio curve of Fig. 2,

$$h = KU_p^2 \quad \text{.....[10]}$$

where K is a constant for any one line of geometrically similar fans operating at the same point on the ratio curve of Fig. 2. The value of K varies, of course, with the value of the velocity and pressure ratios, but for any one given ratio the value of K is constant for a complete series of geometrically similar fans.

The head in feet of air is related to the pressure in inches of water by the following commonly used equation:

$$hd = p\frac{d_w}{12} \quad \text{.....[11]}$$

Eliminating h between [10] and [11] and combining all constants into one new constant k,

$$p = kdU_p^2 \quad \text{.....[12]}$$

Hence, for two similar fans operating at different tip speeds, but at the same point on the ratio curve of Fig. 2, and handling air of the same density,

$$\frac{p_2}{p_1} = \left(\frac{U_{p2}}{U_{p1}}\right)^2 \quad \text{.....[13]}$$

However, from equation 6,

$$\left(\frac{U_{p2}}{U_{p1}}\right)^2 = \left(\frac{N_2D_2}{N_1D_1}\right)^2 \quad \text{.....[14]}$$

Substituting [14] into [13],

$$\frac{p_2}{p_1} = \left(\frac{N_2D_2}{N_1D_1}\right)^2 \quad \text{.....[15]}$$

For two fans of the same diameter operating at the same corresponding point, equation 15 reduces to

$$\frac{p_2}{p_1} = \left(\frac{N_2}{N_1}\right)^2 \quad \text{.....[16]}$$

This is the fundamental relationship from which the pressure may be computed when the speed of a given size fan is changed. For two different sized fans operating at the same speed, equation 15 reduces to

$$\frac{p_2}{p_1} = \left(\frac{D_2}{D_1}\right)^2 \quad \text{.....[17]}$$

When using equations 15 to 17 inclusive, either the static pressure or the total pressure may be used. However, the same pressure—either static or total—must be used in both the numerator and denominator of the equation; do not mix the two in the same equation.

Variation in Horsepower

The brake horsepower required to lift a given weight of air through a given elevation is computed by the following fundamental formula.

$$(hp) = \frac{Wh}{33{,}000\,E} \quad \text{.....[18]}$$

Converting this formula into the commonly used units of cfm of standard air [density = 0.075 lb per cu ft. Standard Test Code, National Association of Fan Manufacturers] and pressure in inches of water, this formula reduces to

$$(hp) = \frac{Vp}{6357\,E} \quad \text{.....[19]}$$

Or, for different air volumes and pressures, but at constant efficiency,

$$\frac{(hp)_2}{(hp)_1} = \frac{V_2p_2}{V_1p_1} \quad \text{.....[20]}$$

Substituting equations 9 and 15 into 20, we obtain

$$\frac{(hp)_2}{(hp)_1} = \left(\frac{N_2}{N_1}\right)^3\left(\frac{D_2}{D_1}\right)^5 \quad \text{.....[21]}$$

For the same sized fans running at different speeds, $D_1 = D_2$, and equation 21 reduces to the following commonly used fan law.

$$\frac{(hp)_2}{(hp)_1} = \left(\frac{N_2}{N_1}\right)^3 \quad \text{.....[22]}$$

For two different sized fans running at the same speed, equation 21 reduces to the following commonly used fan law.

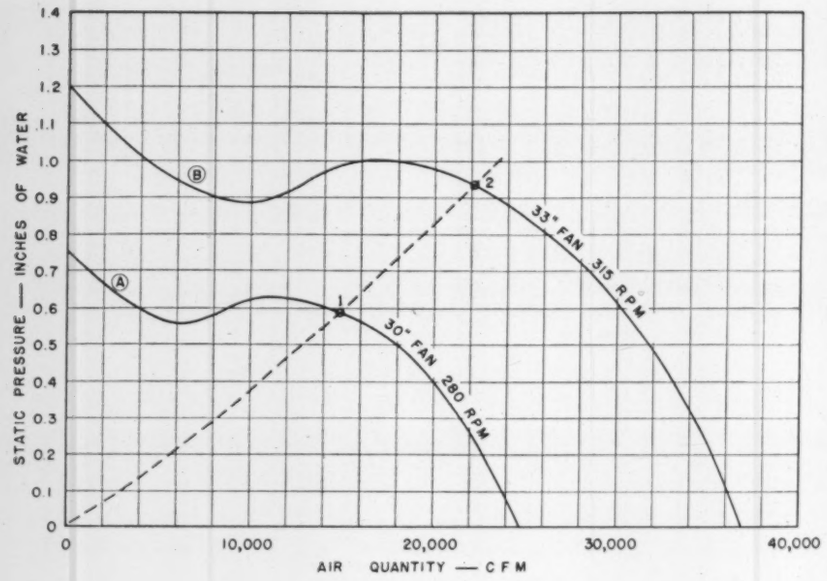


Fig. 3—Performance curve *B* was computed from performance curve *A* by means of the fan laws. The dotted curve is a curve of constant velocity ratio and constant fan efficiency.

$$\frac{(hp)_2}{(hp)_1} = \left(\frac{D_2}{D_1}\right)^5 \quad \text{.....[23]}$$

When using equation 19 to compute the brake horsepower required, either the static pressure or total pressure may be used. However, the mechanical efficiency must be used with the total pressure, and the static efficiency with the static pressure. If this precaution is observed, the same answer will be obtained for the brake horsepower regardless of whether static or total pressure is used in equation 19.

Two Quantities Determine Performance

If a series of air quantities is computed by means of equations 1 and 2 for fans of different sizes and speeds, the velocity ratio will be constant for each of the computed air quantities. Therefore, it is evident from Fig. 2 that the pressure ratio must also remain constant. If the pressure ratio is constant, the pressure against which the fan will deliver the increased volume of air must also increase if either the fan speed or its diameter are increased.

If both the air volume and the pressure against which a fan is operating are increased by a change of either diameter or speed, it is obvious that the horsepower required by the fan will also increase.

Summarizing, it is important to bear in mind that the performance of a fan operating at a given velocity ratio is determined by any two of the following five quantities:

1) Air delivery (cfm).
2) Pressure.
3) Horsepower.
4) Diameter of wheel.
5) Speed (rpm).

If the velocity and pressure ratios are to remain constant, not more than two of the above quantities can be changed independently. The value of the remaining three is determined wholly by the values assumed for the two independent quantities. Thus, if the diameter of a fan is held constant while its speed is changed, or if both its diameter and speed are changed, there will be a change in the air delivery, pressure, and horsepower of the fan.

Example 1—A 30 in. fan running at 280 rpm delivers 12,200 cfm against a static pressure of 5⅛ in. The horsepower required is 2.03. If a geometrically similar fan of 33 in. diameter is operated at a speed of 315 rpm, find its cfm, static pressure, and horsepower.

Solution—Using equation 9,

$$V_2 = 12,200 \times \frac{315}{280}\left(\frac{33}{30}\right)^3 = 18,268 \text{ cfm.}$$

Using equation 15,

$$p_2 = 0.625\left(\frac{315}{280} \times \frac{33}{30}\right)^2$$

$$= 0.96 \text{ in. static pressure.}$$

Using equation 21,

$$(hp)_2 = 2.03\left(\frac{315}{280}\right)^3\left(\frac{33}{30}\right)^5$$

$$= 4.65.$$

In Fig. 3, curve *A* shows the performance of a 30 in. fan at 280 rpm. Curve *B* for a 33 in. fan running at 315 rpm was computed from curve *A*. For example, point *2* of curve *B* was computed from point *1* of curve *A* in the manner illustrated in example 1. By assuming a number of different points on curve *A*, corresponding points on curve *B* were then computed and plotted.

At both points *1* and *2* the pressure and velocity ratios and the efficiencies are the same. The dotted curve through points *1* and *2* is a curve of constant velocity or constant pressure ratio. If a number of different performance curves are drawn in Fig. 3, the points at which these curves are intersected by the dotted curve *1-2* are all corresponding points. In addition, the points intersected by the dotted curve *1-2* would, of course, all have exactly the same efficiency. Therefore, a curve such as *1-2* might also be called a *curve of constant efficiency*.

❖ ❖ ❖

Pure Air.—Because pure air as well as good food is essential to health, chemists in the company's industrial hygiene laboratories continually analyze shop air in all Westinghouse plants to safeguard workers against dust, fumes, gases, mists and vapors. The increased use of substitutes in manufacturing processes has created new problems in industrial hygiene. For example, when toluol was used as a paint and varnish thinner, a ventilating system was adequate to draw the fumes from paint tanks and prevent them from reaching workmen. But now that toluol is needed in the manufacture of explosives, a substitute is being used, which makes it necessary for all paint tanks to be covered.

❖ ❖ ❖

In our March issue we reproduced a blotter with the phrase "Nothing matters right now but winning the war, because nothing will matter if we don't win it." Oliver J. Prentice had the blotters printed to enclose in his correspondence and to distribute to friends. . . . Following its appearance in HPAC, Mr. Prentice received a request from one of the large ordnance plants for permission to use the phrase on posters placed throughout the plant—which request was of course granted.

FLOW OF SOLIDS IN PIPING

Practical Data on Pumping and Piping Sludges, Muds, and Suspensions in Industrial Wartime Processes ... By H. E. Babbitt and D. H. Caldwell

SUMMARY—Knowledge of the flow characteristics of muds, sludges, and solids in solution is needed in many industrial wartime processes, in oil well drilling, paper making, water treatment, sewage treatment, dredging, etc. Equations were presented in the July HPAC from which the pipe friction losses necessary to design the piping and select the pumping equipment may be computed for the flow of all types of such materials commonly encountered in practice. This month, measurement of the sludge constants is discussed, and examples showing the practical applications of the equations are given . . . The authors are, respectively, professor of sanitary engineering, and research assistant in civil engineering, at the University of Illinois

VALUES OF yield value, τ_y, and the coefficient of rigidity, η, may be measured in a variety of ways. Any existing pipe line through which the sludge may be pumped can be used in their measurement. The observations to be made under such conditions are the friction losses between two points on the pipe line, at two or more velocities below critical. These observations are plotted on a diagram with the shear at the pipe wall, τ_p, as the ordinate, and eight times the velocity divided by g times the diameter, $(8V/gD)$ as the abscissa. The slope of the line formed by connecting the points is the coefficient of rigidity and the intercept of the line on the τ_p axis is four-thirds the yield value, as is seen by rewriting equation 1 [p. 423, July HPAC] in the form

$$\tau_p = \frac{4}{3}\tau_y + \eta\frac{8V}{gD} \quad \text{.....[7]}$$

The values of τ_p are obtained from the head losses, expressed in feet of flowing material, by means of the equation

$$\tau_p = \frac{H\rho R}{2L} \quad \text{.....[8]}$$

The Stormer viscometer can be adapted to the measurement of the yield value τ_y, and the coefficient of rigidity, η, of a sludge by slight modifications. Sewage sludges in particular have numerous large particles that render the standard Stormer cup useless by binding the rotating cylinder. To overcome this difficulty, and yet to maintain the clearances at a minimum, the cup illustrated in Fig. 8 was designed. Although turbulence occurs sooner with the modified cup than with the standard cup, interference of the particles with the rotating cylinder is believed to have been eliminated.

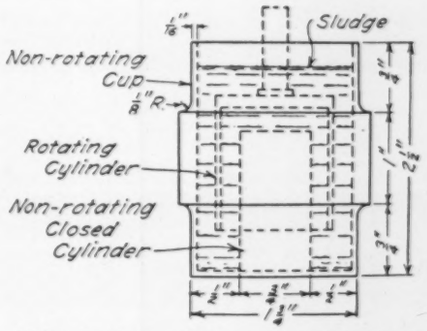
The procedure when using the modified Stormer viscometer for the measurement of τ_y, the yield value, and η, the rigidity, is as follows: The material to be measured is poured into the cup to exactly ¼ in. from the top, and the rotating cylinder is inserted. A known weight to act as a driving force is attached to the string wound on the drum; the brake is released and the time for the cylinder to make 100 revolutions is noted, and recorded as revolutions per second, together with the corresponding driving force in grams. After several readings have been taken at various values of driving force, a new cupful of material is taken in order to eliminate, as much as possible, errors due to thixotropy. [Thixotropy is the property of some gels to become fluid when shaken or agitated. The phenomenon is also reversible.]

Plots of observations made with a modified Stormer viscometer for four clay sludges are shown in Fig. 9. The driving force in grams is plotted as the ordinate, using W as the symbol. The speed of revolution is plotted as the abscissa using N (revolutions per second) as the symbol. Fig. 10 is a plot of the pipe flow characteristics of the same clay sludges with the shear at the pipe wall, τ_p, plotted as the ordinate, and eight times the velocity of flow divided by g times the diameter as the abscissa. The similarity of the graphs is apparent, and is the basis for converting the Stormer data to the pipe flow constants τ_y and η. It has been found that in Fig 9 the intercept on the W axis of a line connecting the points representing

Symbols

A = area of pipe, sq ft;
D = diameter of pipe, ft;
f = friction factor in equation 6;
g = acceleration due to gravity, ft per sec per sec;
H = difference in static head between two points in a pipe, ft of flowing substance;
L = length of pipe, ft;
N = speed of revolution in modified Stormer viscometer, revolutions per sec;
R = radius of pipe, ft;
(Re) = Reynolds number, $DV\rho/\mu$, dimensionless;
Q = rate of flow, cu ft per sec;
V = mean velocity of flow in pipe, ft per sec;
V_c = critical velocity, ft per sec;
V_{lc} = lower critical velocity, ft per sec $[(Re) = 2000]$;
V_{uc} = upper critical velocity, ft per sec $[(Re) = 3000]$;
W = driving force in Stormer viscometer, grams;
W_y = magnitude, in grams, of ordinate of point of intersection on the W axis of a line connecting the points representing driving force W and speed of revolution N (see Fig. 9);
μ = coefficient of viscosity, lb per sec ft;
η = coefficient of rigidity, lb per sec ft;
λ = slope of line connecting points representing driving force W, and corresponding speed of revolution N, in the Stormer viscometer (see Fig. 9);
ρ = density of flowing substance, lb per cu ft;
τ_p = shearing stress in a flowing material at the boundary or pipe wall, lb per sq ft;
τ_y = shearing stress at yield point of plastic material, called yield value, lb per sq ft.

Fig. 8—Modified Stormer cup.



Note: Surfaces in contact with sludge must not be highly polished.

driving force, W, and speed of revolution, N, is proportional to the yield value, τ_y, and that the slope, λ, of the same line is proportional to the coefficient of rigidity, η. Table 4 presents a comparison of values of τ_y and W_y and η and λ, and demonstrates that the modified Stormer viscometer may be used in measuring the yield value, τ_y, and the rigidity, η, of a sludge.

Since the modified Stormer cup shown in Fig. 8 has been carefully standardized, any Stormer viscometer can be adapted to the measurement of τ_y and η simply by using an identical cup. The following equations can be used for converting Stormer data to pipe flow constants:

$$\tau_y = 0.0020\, W_y \quad \text{.....[9]}$$
$$\eta = 0.0035\, \lambda \quad \text{.....[10]}$$

At low rates of shear in the modified Stormer viscometer corresponding to small speeds of revolution the relationship between the driving force and the speed of revolution is not linear, which results in the line connecting the points representing driving force and corresponding speed of revolution bending toward the origin. The explanation of this is that, at low rates of shear, the material shears first at the point of greatest stress which is in the layers of material next to the rotating cylinder. As the rate of shear is increased, shear takes place progressively further from the rotating cylinder until, at some point, shear is taking place from the rotating cylinder to the cup sides. At this point the relation between the increase in driving force and the increase in speed of revolution becomes linear, and continues in this manner until turbulence is introduced by the high rates of shear. It is essential that the driving force and speed of revolution be measured in the area bounded by lines AB and CD in Fig. 9 as only between these lines is there a linear relationship between the increase in driving force and the increase in speed.

Viscometers suitable for measuring the yield value, τ_y, and the rigidity, η, of a sludge include (1) rotating cylinder viscometers, of which the Stormer and Kampf are examples; (2) falling ball viscometers; (3) swinging pendulum vis-

Table 4--Relation of τ_y to W_y, and η to λ

Test Substance No.	Sp. Gr.	Per Cent Solids	Yield Value τ_y	W_y	Ratio τ_y/W_y	Coeff. of Rigidity η	λ	Ratio η/λ
I Clay Susp.	1.49	52.0	0.72	355	0.0020	0.030	8.0	0.003
II* Clay Susp.	1.49	52.3	0.74	370	0.0020	0.036	9.5	0.003
III* Clay Susp.	1.44	48.9	0.418	205	0.0020	0.022	7.0	0.003
IV* Clay Susp.	1.40	45.3	0.245	124	0.0019	0.014	4.4	0.003
V* Clay Susp.	1.36	42.2	0.139	66	0.0021	0.013	4.0	0.003
VI* Cylinder Oil	0.88					0.074	21.2	0.003
Average					0.0020			0.003

*See Figs. 9 and 10.

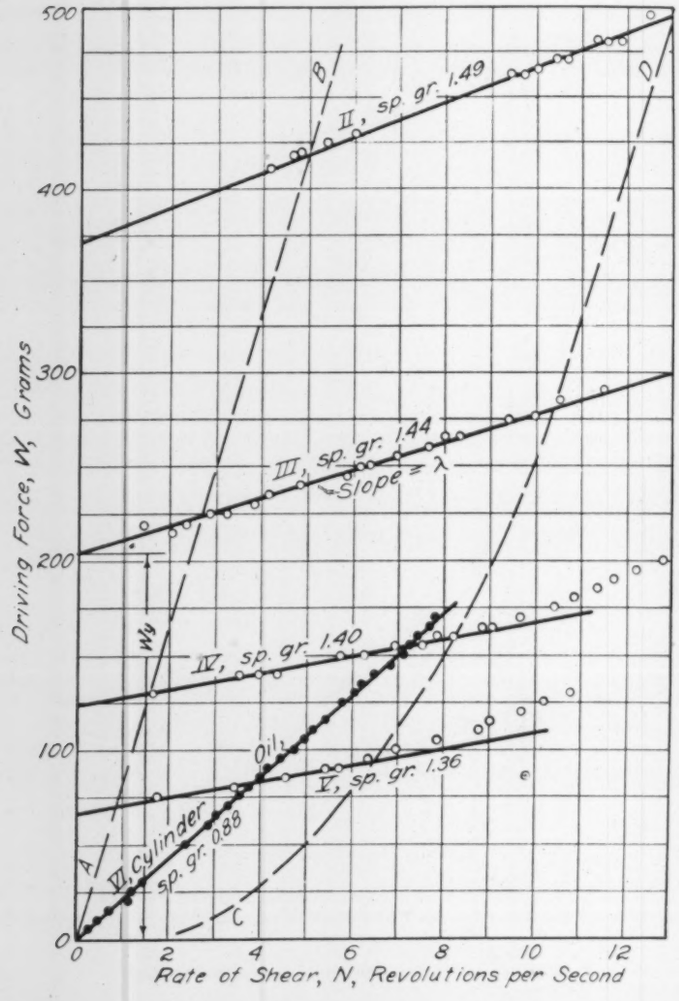


Fig. 9—Flow of clay sludge in Stormer viscometer

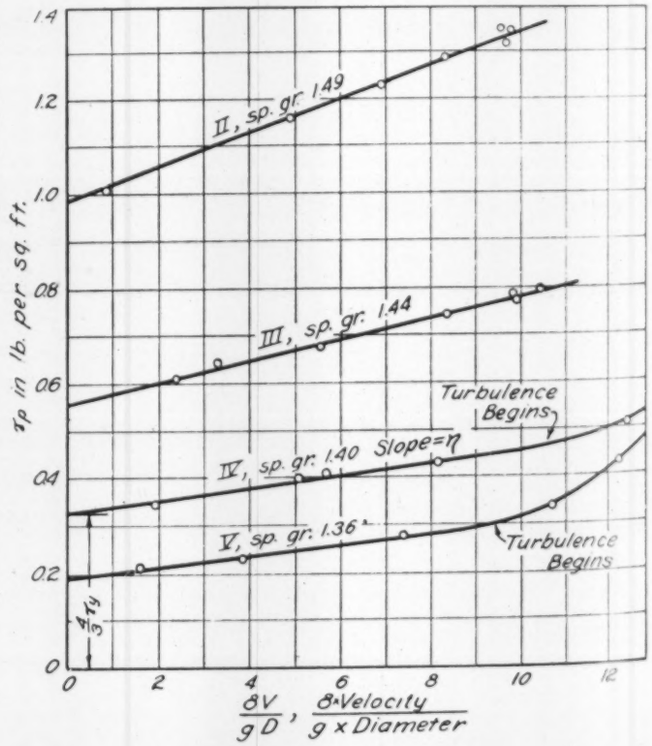


Fig. 10—Flow of clay sludge in pipes

cometers; and (4) capillary tube viscometers. Of these four only the last one will measure the true values of the constants τ_y and η. The underlying principles of some of these viscometers are explained in detail in the first and second reports on viscosity and plasticity of the Academy of Sciences of Amsterdam, published in 1935 and 1938, respectively.

Table 5 presents the results of tests on various sludges to determine the values of the plastic flow constants, τ_y and η. Although the values of the constants vary over wide ranges it is possible to predict the yield values, as a function of the solids concentration, for certain types of sludges. Fig. 11 is a plot of the logarithm of the yield value against the percentage solids for a ball clay tested during this investigation. In this particular case an equation of the form

$$\tau_y = 10^{(0.078C - 2.32)}$$

where C is the per cent by weight of solids, fits the data. Much more data are required in order to predict the yield values of other types of sludges. Such factors as concentration of suspended matter, size and character of particles of suspended matter, nature of the continuous phase, temperature, thixotropy, gas content, and agitation may affect the values of the constants τ_y and η.

Table 5--Constants for Plastic Flow of Sludge

Source and Description of Sludge	Temperature, F	Per Cent Moisture (by wt.)	Volatile Solids, Per Cent of Total Solids (by wt.)	Sp. gr.	Diam. of Pipe, In.	Yield Value τ_y	Coefficient of Rigidity η	Source of Information (see p. 427, July HPAC)
Sewage Sludge								
Indlps., Ind., Activated	36	98.6	66.6	1.008	3/8	0.0	0.001	
Indlps., Ind., Primary	40	98.2	68.4	1.005	3/8	0.020	.....	
Indlps., Ind., Digested	42	92	53.4	1.032	3/8	0.405	0.032	
Indlps., Ind., Digested	55	92	53.4	1.023	3/8	0.243	0.029	
Indlps., Ind., Digested	58	96	53.5	1.019	3/8	0.0	.....	
Decatur, Ill., Digested	60	86	33.2	1.068	3/8	0.581	0.040	
Decatur, Ill., Digested	60	90	34.8	1.050	3/8	0.098	0.015	
Sprgfld.,Ill., Digested	58	92.6	44.8	1.026	3/8	0.315	0.030	References
Sprgfld.,Ill., Digested	60	93.7	44.6	1.021	3/8	0.098	0.018	No. 1,2
Decatur, Ill., Imhoff	61	88.3	40.0	1.049	3/8	0.405	0.035	Bibliography
Exp. Plant, Primary	53	93.3	78.1	0.991	3/8	0.090	0.019	
Danville, Ill.,Primary	44	97.3	75.3	1.003	3/8	0.0	.....	
Kankakee, Ill.,Digested	46	92.7	50.8	1.034	3/8	0.026	0.017	
Danville, Ill.,Digested	46	93	48.5	1.030	3/8	0.234	0.029	
Danville, Ill.,Digested	122	93	48.5	1.008	3/8	0.072	0.014	
Danville, Ill.,Digested	71	93	48.5	1.023	3/8	0.180	0.019	
Danville, Ill.,Digested	40	92	48.5	1.026	3/8	0.205	0.026	
Decatur, Ill., Digested	70	87	33	1.05	2	0.141	.....	
Decatur, Ill., Digested	70	91	33	1.05	2	0.034	.....	
Decatur, Ill., Imhoff	60	86	40	1.06	1	0.065	0.165	
Decatur, Ill., Imhoff	60	86	40	1.06	2	0.065	0.165	
Decatur, Ill., Imhoff	60	86	40	1.06	3	0.065	0.165	
Calumet, Ill., Imhoff	36-74	90	....	....	8	0.017	0.026	
Calumet, Ill., Imhoff	36-74	87	....	....	8	0.044	0.040	
Calumet, Ill., Imhoff	36-74	88	....	....	8	0.033	0.036	
Calumet, Ill., Imhoff	36-74	89	....	....	8	0.024	0.034	
Calumet, Ill., Imhoff	36-74	90	....	....	8	0.017	0.026	
Calumet, Ill., Imhoff	36-74	91	....	....	8	0.013	0.018	
Calumet, Ill., Imhoff	36-74	92	....	....	8	0.006	0.018	
Calumet, Ill., Imhoff	36-74	93	....	....	8	0.003	0.016	
Calumet, Ill., Imhoff	36-74	94	....	....	8	0.0015	0.014	Reference
Calumet, Ill., Imhoff	54-67	89	....	....	12	0.020	0.0514	No. 4
Calumet, Ill., Imhoff	54-67	90	....	....	12	0.014	0.035	Bibliography
Calumet, Ill., Imhoff	54-67	91	....	....	12	0.009	0.032	
Calumet, Ill., Imhoff	54-67	92	....	....	12	0.0045	0.036	
Calumet, Ill., Imhoff	54-67	93	....	....	12	0.0026	0.025	
Calumet, Ill., Imhoff	54-67	94	....	....	12	0.0015	0.024	
Birmingham, England	.....	90	....	....	12	0.054	0.03*	
Manchester, England	.....	89	....	....	10	0.155	0.03*	
Glasgow, Scotland	.....	88	....	....	9	0.036	0.03*	
Wolverhampton, England	.....	90	....	....	4	0.070	0.03*	
Stuttgart, Germany, Digested	57-68	85	....	....	7.9	0.412	0.089	
Stuttgart, Germany, Digested	57-68	86	....	....	7.9	0.276	0.096	
Stuttgart, Germany, Digested	57-68	87	....	....	7.9	0.199	0.093	
Stuttgart, Germany, Digested	57-68	88	....	....	7.9	0.153	0.089	
Stuttgart, Germany, Digested	57-68	89	....	....	7.9	0.118	0.080	
Stuttgart, Germany, Digested	57-68	90	....	....	7.9	0.100	0.077	Reference
Stuttgart, Germany, Digested	57-68	91	....	....	7.9	0.077	0.079	No. 5
Stuttgart, Germany, Digested	57-68	82	....	....	7.9	0.128	0.078	Bibliography
Stuttgart, Germany, Digested	57-68	84	....	....	7.9	0.089	0.076	
Stuttgart, Germany, Digested	57-68	86	....	....	7.9	0.061	0.068	
Stuttgart, Germany, Digested	57-68	88	....	....	7.9	0.046	0.086	
Stuttgart, Germany, Digested	57-68	90	....	....	7.9	0.031	0.062	
Calumet, Ill., Imhoff	....	88	....	....	5	0.060	0.021	Unpublished
Calumet, Ill., Imhoff	....	90	....	....	5	0.020	0.019	Data of Chicago
Calumet, Ill., Imhoff	....	92	....	....	5	0.008	0.013	Sanitary District
Clay								
Illinois Yellow Clay	76	48	0	1.49	1	0.720	0.028	
Illinois Yellow Clay	76	48	0	1.49	2	0.720	0.028	Reference
Illinois Yellow Clay	76	48	0	1.49	3	0.720	0.028	No. 1
Slurry from Water Plant	79	81.4	....	1.13	4	0.020	0.005	
Slurry from Water Plant	86	76.6	....	1.175	4	0.056	0.005	Reference
Slurry from Water Plant	89	70.9	....	1.225	4	0.117	0.005	No. 3
Slurry from Water Plant	91	67.5	....	1.225	4	0.158	0.005	Bibliography
Slurry from Water Plant	87	64.8	....	1.285	4	0.215	0.005	
Slurry from Water Plant	65	86.4	....	1.17	4	0.011	0.005	
Tennessee Ball Clay with Water as Dispersion Medium	82	84.9	0	1.110	..	0.059	0.011	
	84	79.3	0	1.140	..	0.201	0.014	
	82	77.2	0	1.162	..	0.340	0.015	
	82	76.8	0	1.162	..	0.413	0.017	
	82	75.2	0	1.145	..	0.532	0.019	Modified
Tennessee Ball Clay with Glycerine as Dispersion Medium	82	85.2	0	1.092	..	0.081	0.0119	Stormer
	82	83.5	0	1.071	..	0.123	0.0144	Viscometer
	82	81.3	0	1.105	..	0.178	0.0166	
Illinois Yellow Clay with Water as Dispersion Medium	80	66.0	0	1.32	..	0.030	0.011	Reference No. 1
	78	55.0	0	1.42	..	0.132	0.017	
	80	51.5	0	1.44	..	0.208	0.024	
	80	51.	0	1.46	..	0.401	0.023	
	79	48.	0	1.49	..	0.709	0.028	
Bentonite Paste	Room	55.4	....	....	..	1.73	0.022	Reference
Kaolin Paste	Room	45.0	....	....	..	2.35	1.72	No. 8
Paint Paste	Room	68.0	....	....	..	1.80	0.364	Bibliography
Paint Paste	Room	....	....	....	..	1.50	0.270	

*Assumed.

Practical Applications

The equations presented herein for various conditions can be used for two principal purposes: (1) The measurement of the yield value, τ_y, and the rigidity, η, of the sludge; and (2) in the design of pipe sizes and in computing the capacity of equipment for conveying and pumping sludge. The factors involved in the use of the formulas for either of these purposes are: D, L, Q, H, τ_y, η, and ρ.

In the design of pipe sizes and pumping equipment for any particular sludge it is necessary to know its yield value and coefficient of rigidity. Where these values cannot be measured they must be estimated from the assumed characteristics of the sludge and such data as are given in Table 5. Because of the comparatively wide variations in values of τ_y and η between sludges with apparently similar characteristics and because of the limited data available, the values of τ_y and η found in practice may vary considerably from those assumed in design. The designer should, therefore, assume values which will assure results within safe limits. The field is open for further research in determining values of these characteristics of sludges and correlating them with other characteristics.

When τ_y, η, and the type of pipe to be used are known and it is desired to determine the friction loss H, the remaining factors Q, L, and D must be known or assumed for the particular conditions. The first step is to determine the values of the average velocity from the expression $V = (4Q/\pi D^2)$. The value of the critical velocity is then computed by equation 3 or 4. If V is greater than V_{uc}, turbulent flow exists and H is evaluated by means of

the friction factor chart, Fig. 5 [p. 426, July HPAC]. To use this chart, the Reynolds number is computed using the viscosity of the dispersion medium of the sludge. If the value of V is less than V_{1c}, plastic flow exists and the friction loss H is determined by substitution in equation 2.

For example, let it be required to determine the pressure required to pump a sludge through 4000 ft of 6 in. cast iron pipe at the rate of 600 gpm. The characteristics of the sludge will be assumed to be as follows: $\tau_y = 0.020$, $\eta = 0.020$, and $\rho = 65$. The viscosity of the dispersion medium is assumed to be the same as that of water. The temperature is assumed to be 60 F.

The steps in the solution are as follows:

1) Determine the critical velocity, using equation 4 on p. 424, July HPAC:

$$V_{uc} = \frac{1500 \times 0.020 + 1500 \sqrt{(0.020)^2 + \dfrac{(0.5)^2 \times 0.020 \times 65 \times 32.2}{4500}}}{0.5 \times 65} = 3.3 \text{ fps}$$

2) Determine velocity at which sludge will flow in pipe at specified rate

$$V = \frac{Q}{A} = \frac{600}{(0.5)^2 \times 0.785 \times 60 \times 7.5} = 6.8 \text{ fps}$$

3) If the velocity found in step 2 is less than the critical velocity in step 1 the plastic flow equation [equation 2, p. 424, July HPAC] is used. If the actual velocity is greater than the critical velocity, then the Reynolds number is computed for the actual velocity as follows:

Find the viscosity, μ, for water from Table 3 [p. 427, July HPAC] at 60 F. Then

$$(R_e) = \frac{DV\rho}{\mu} = \frac{0.5 \times 6.8 \times 65}{7.6 \times 10^{-4}} = 290{,}000$$

4) Using the Reynolds number found in step 3, find the friction factor. The friction factor $f = 0.020$ is commonly used for old cast iron pipe.

5) Substitute this value of f in equation 6:

$$H = \frac{0.02 \times 4000 \times 6.8^2}{0.5 \times 2 \times 32.2} = 115 \text{ ft of sludge.}$$

(Note: Equation 6 was incorrectly shown in July; the 2 in the numerator should be in the denominator)

6) The pressure loss is then $115 \times 65 = 7500$ lb per sq ft $= 52$ psi.

As an illustration of the use of the plastic flow equation, let it be required to pump Imhoff tank sewage sludge through 2500 ft of 8 in. cast iron pipe at the rate of 400 gpm.

We must first either measure or otherwise obtain the constants (yield value and rigidity) characteristic of an Imhoff sludge. From Table 5 it is observed that the Imhoff sludge of Decatur, Ill. (No. 10), was among the thickest of those measured, hence the use of the constants of the Decatur sludge will be on the safe side. These constants are: $\tau_y = 0.405$ lb per sq ft; $\eta = 0.035$ lb per ft sec; $\rho = 1.049 \times 62.5 = 65.6$ lb per sq ft.

1) Following the procedure of the preceding example, first compute the critical velocity by equation 3, from p. 424, July HPAC:

$$\frac{1000 \times 0.035 + 1000 \sqrt{(0.035)^2 + \dfrac{(8/12)^2 \times 0.405 \times 65.6 \times 32.2}{3000}}}{(8/12) \times 65.6} = 8 \text{ fps}$$

2) Next compute the velocity at which the sludge will flow at the specified rate:

$$V = \frac{Q}{A} = \frac{400}{(8/12)^2 \times 0.785 \times 60 \times 7.5} = 2.54 \text{ fps}$$

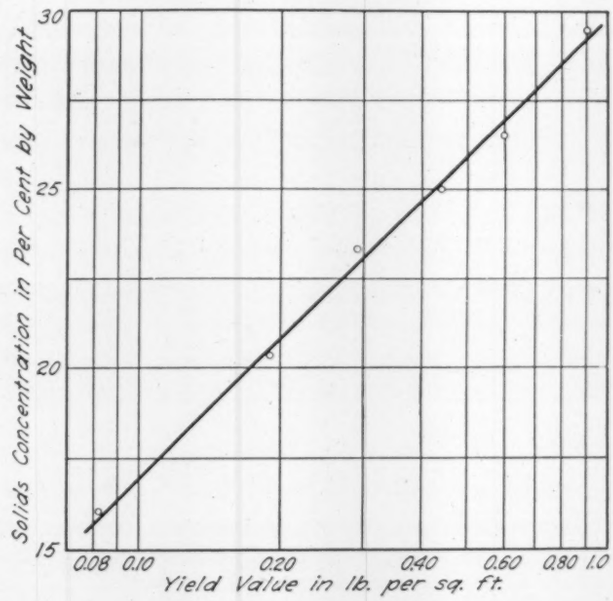
3) The velocity found in step 2 is less than the critical velocity from step 1. To determine the friction loss, therefore, the plastic flow equation is used as follows:

From equation 2, on p. 424, July HPAC

$$H = 32 \times 2500 \left[\frac{0.405}{6 \times 65.6 \times (8/12)} + \frac{0.035 \times 2.54}{32.2 \times 65.6 \times (8/12)^2} \right] = 131 \text{ ft of sludge}$$

4) The pressure loss is then $131 \times 65.6 = 8600$ lb per sq ft $= 60$ psi.

Fig. 11—Variation of yield value with concentration of suspended matter for Tennessee ball clay



WPB BANS COPPER IN BUILDING CONSTRUCTION

Use of copper and copper base alloy is forbidden in building construction by conservation order M-9-c-4, issued July 22 by the WPB's director general for operations. The order does not, however, affect wiring. To conserve copper urgently needed in war production, the order forbids delivery, acceptance of delivery, or use, installation or connection, of any copper or copper base alloy pipe, tubing or building material containing 5 per cent or more copper except by specific authorization by the director general. Exceptions are uses of 25 lb or less to repair a building where the metal so used is to replace copper building material previously installed, and use by the armed services within the terms of the regulation entitled "Prohibited Items for Construction Work" dated April 1, 1942, issued by the Army and Navy Munitions Board.

CODE FOR PRESSURE PIPING

Sabin Crocker Calls Attention to a Few Editorial Changes in New ASA Code

THE EDITOR—

In connection with the series of articles on the 1942 revision of the American standard code for pressure piping which appeared in your January through July issues, I should like to call attention to a few editorial changes in the code which were approved at a meeting of the subcommittee on plan, scope and editing held in New York on February 11.

Since the January and February articles were already published at that time, these changes refer to the two articles appearing in those issues.

In all sections of the code, a note was introduced to permit using the actual measured wall thickness and actual measured outside diameter of pipe on hand or in stock when computing the maximum internal service pressure. To clarify the procedure where the actual dimensions of the pipe are not available, as is the case ordinarily, an additional sentence as follows was added to this note: "For design, the outside diameter of pipe as given in tables of standards and specifications shall be used in obtaining the value of t_m."

Where reference to factory made welding fittings occurs throughout the code, both the American standard for steel butt welding fittings, ASA B16.9, and the proposed American standard for steel socket welding fittings are now mentioned. Several manufacturers of socket welding fittings already are producing fittings in conformance with the new dimensions.

The prohibition on use of bar stock nuts has been eliminated for sizes ½ in. and smaller to conform with action taken by the section on bolting of ASTM subcommittee XXII. Under war emergency conditions, nuts in these small sizes are made almost exclusively from bar stock so that it is not feasible to prohibit them for the duration at least. In connection with their use in flanged fittings, it was felt that splitting of nuts in these small sizes, if experienced, would not constitute a serious hazard, as would be the case for the larger nuts used in large size flanged fittings.

Washers formerly were specified to be of the same material as nuts. While from the standpoint of creep resistance, this would be desirable, washers are not generally available to match the materials used in alloy nuts. Since forged or rolled carbon steel washers have been found satisfactory even when used where alloy nuts are specified, the requirement has been changed to make them acceptable. No particular hazard to safety is involved in the change.

Under oil piping for power plant service, a clarification of the design temperature has been made. Whereas formerly it was not clear what temperature was to be used in the design of such piping, it is now expressly stated that the actual temperature of the oil, or that of saturated steam corresponding to the oil pressure, whichever is higher, shall be considered. — SABIN CROCKER, chairman, subcommittee I on plan, scope and editing, ASA B31; member of HPAC's board of consulting & contributing editors.

COMPRESSED AIR SPEEDS BOMBER PART TESTING JOB

BOMBER PART testing has been speeded at an aeronautical plant by a device known as a "comparator" which operates in connection with a Rockwell hardness gage.

Russell Gross of the Compressed Air Institute, with whom E. J. Shildkret, engineer and codesigner of the device, discussed this new compressed air application, explains it as follows: The comparator is used as an accessory to the Rockwell gage. It comprises a table mounted yoke which supports a penetrator placed over an anvil. The die end of the penetrator is the same size as that used in the Rockwell gage. The anvil moves upward against the penetrator under pressure of a piston operated by compressed air under 100 psi. A piece being tested is thus pressed against the spherical die with pressure sufficient to indent its surface. The depth of the indentation is shown by a dial indicator which records any upward motion of the die. The softer the metal, the greater the indentation. A foot controlled air valve allows the operator free use of both hands.

Compressed air operated tester speeds production of bomber parts

To test a number of similar parts, one of correct hardness (as determined by the Rockwell gage) is used to calibrate the comparator. This piece is subjected to pressure in the comparator, at which time the position of the indicator needle is noted. Subsequent pieces, if of proper hardness, will give the same reading. If too soft, the die penetrates deeper causing the needle to pass the established reading.

PRACTICAL PIPING PROBLEMS

W. H. Wilson Stresses the Importance of Safety and Economy in Piping Practice

SUMMARY—A baby was killed recently by steam escaping from an unused radiator connection in an apartment. Mr. Wilson stresses the importance of plugging unused pipe lines, and of placing valves and drain connections in plant piping for convenient operation and easy inspection. . . . . Mr. Wilson, who has had many years of experience in practical piping work, is a member of HPAC's board of consulting & contributing editors

NEWSPAPERS IN a large city recently published an account of a fatal accident caused by escaping steam. The victim was a baby 16 months old. The family had moved into an apartment the previous day. The child was sleeping in a crib in the bedroom. A steam radiator of the heating system had been removed from the room some time in the past. A sudden change in the weather caused the caretaker of the building to turn on the steam for the heating system that night. At the time the radiator was removed the steam supply pipe and valve were left in place. The baby's crib was near the valve and the escaping steam scalded the child. Another child sleeping in a bed on the opposite side of the room was not harmed.

Care should be taken that other such accidents do not occur. Provision should always be made for taking care of the valve and steam supply when a radiator is removed. The newspaper account of the accident stated that it was said the children may have opened the valve prior to the time steam was turned on the heating system of the building. This would be all the more reason for removing the valve and plugging the steam supply line (or screwing a plug in the open end of the valve) at the time the radiator was disconnected.

Valves are often installed in industrial plants as drips, drains, blowoffs, test valves and stop cocks, with one end open to the atmosphere, or with a pipe connection with an open end leading to a drain line or sewer. In many cases the open end is not visible. Drip or drain valves for oil, gas, acids, and expensive liquids should be placed as conveniently as possible for periodic inspection and the open end of the valve should be plugged when not in actual use. Under the best of operating conditions, with changing of workmen on different shifts and other maintenance and operating problems, these valves have been left open at the wrong time and been the cause of trouble. This happens at times when the discharge outlet is piped some distance away and connected to an underground drain. Good practice, in many cases, would be to have a funnel or container for the discharge to make it visible, and a drain line from the funnel to carry the discharge away.

I recall an incident where the water level float controlled valve of a boiler room feedwater heater was leaking, allowing the excess water to pass from the heater and out through the discharge piping—most of which was under a concrete floor leading to an outside drain line. The waste, which included the fresh water to make up the lost water and the heat loss in the water that was flowing out the drain on account of lack of proper inspection and care of equipment, represented an operating loss well worth correcting. A container in the shape of a funnel to receive the water flowing from the heater, permitting visibility and allowing the overflow water to pass to the drain line, would take care of the excess water in case of operating difficulties, and at the same time would call visible attention to matters that should be corrected.

Oil Piping

In a certain forging shop, using fuel oil for the furnaces, the pipe lines for supplying the oil were overhead on the roof trusses with ½ in. drop pipes to the furnaces. The forging work, machinery, and furnaces were moved to a new location in a building some distance away. The overhead piping, including the drop pipes, extending down within 5 ft of the floor line, was left in its original location. The shop was turned over to the supply department and used to store sheet metal. Some grades of sheet steel were given a light coating of this oil while in storage, the oil being taken from the valves on the ends of the drops.

A large amount of oil was lost on one occasion. The supply department was unloading and storing steel sheets at the end of the week when the remainder of the plant was not in operation and the oil pumps were not in service. Some oil was obtained from the drop pipes (oil that remained in the piping). While the oil supply was not normal it was made to fit the situation. At the beginning of the next week, when the furnaces were started before regular plant working hours and no one was in the steel storage, a large amount of oil was lost when the oil pump was started; some of the valves on the drops were open or partially open. When the oil pumps were started oil flowed from these valves on the floor and into an abandoned pipe tunnel and out the tunnel drains.

In addition to the loss of oil, there were some bad feelings between the maintenance and supply departments as to who would take the responsibility for it. The drop pipes should have been removed at the time the furnaces were taken out of service and the openings in the overhead lines plugged. A suitable pipe connection from the fuel oil line at a convenient location, with a lockup valve and the key for the valve in charge of the department using the oil, would have been the proper arrangement from a practical and reasonable standpoint.

Pay close attention to valves. Valves that are leaking increase operating expenses. Blowoffs, drains, and bleeder valves improperly used and handled contribute to operating losses. Years ago I was told, when watching a sleight of hand performer, to "watch his other hand," not the one he uses in doing the trick. Similarly, "watch the other end of the drain valves."

Heating · Piping and Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

HOW ARE WE DOING?

Whether we have just begun to fight or whether we are about to enter the phase of mass production expected to contribute to a long war from which we shall emerge victorious, now is the time to take stock. . . . The factors against our effectiveness stand out conspicuously. We were unprepared in physical equipment and in training. We allowed moral codes and wishful thinking to warp our judgment and we forgot that changes in human nature require hundreds if not thousands of years to become established. We even thought that a sense of fair play would guide combatants.

On the credit side of our accounting may be recorded our confidence in right, our determination and our assurance of ability; our vast supplies of most materials needed; and our capacity for organization and production methods that have attracted world-wide recognition. Engineering societies have recognized their responsibilities and in a war of materials and machines they are masters. . . . Some felt excited lest the activities of technical societies would have to be curtailed but it is significant that more research is under way in the United States than ever before. . . . Some projects have been temporarily discontinued to give way to war projects but the contest is as much a war of ideas as machines. . . . Few engineers are devoting their energies to a consideration of post war problems and no person, engineer or other, has presented a constructive post war program. . . . The American Society of Heating and Ventilating Engineers has contributed through individual members, its research, and its War Service Committee. The Society has maintained its regular program. Its membership has increased and its research progam continued.

I believe that the conclusion of the war will find our Society strengthened in knowledge and in cordial relations, the membership happy in the conviction of work well done in helping to maintain the safest, fairest and most prosperous type of government ever devised.

President

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START WAR ON FUEL WASTE NOW

A MEETING sponsored by the War Service Committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS was held at the Hotel Pennsylvania, New York, Tuesday, July 21, with Walter L. Fleisher presiding, for the purpose of coordinating the efforts of the various organizations in the heating industry who realize the necessity for drastic action by all agencies having control of production, distribution, transportation, price and utilization of fuel. Those in attendance were Marc Bluth, Secretary, *Stoker Manufacturers Association;* Allen Johnson, Director, *Anthracite Industries Laboratory;* John F. Collins, Jr., Secretary-Treasurer, *National District Heating Association;* R. E. Ferry, General Manager, *Institute of Boiler and Radiator Manufacturers;* R. A. Locke, Manager, *Steel Heating Boiler Institute;* J. C. Fitts, Secretary, *Heating, Piping and Air Conditioning Contractors National Association;* Wharton Clay, Secretary, *National Mineral Wool Association;* Robert K. Thulman, Mechanical Engineer, Federal Housing Administration; R. A. Richardson and W. F. Schuyler, *Oil Burner Institute;* J. W. West, Jr., Secretary, *American Gas Association;* A. V. Hutchinson, Secretary, and John James, Technical Secretary, of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Mr. Fleisher briefly stated the purpose of the meeting and reviewed the work of the War Service Committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, which was invited by the Federal Coal and Oil Coordinator to assist in determining what could be done about fuel conservation during the coming heating season. The Committee Chairman, Dr. B. M. Woods, presented the Committee's findings and recommendations on July 3 and the point was emphasized that there were only 90 days until the heating season starts in some of the areas in which a critical fuel situation is anticipated.

Briefly, he said the program covers the following facts and factors:

1. There are only 90 days until the heating season starts in the areas that are considered critical.
2. Shifts of population and expanded building construction due to war industry employment will require delivery of more fuel for the coming season than previously in many areas.
3. Many existing plants now burning oil formerly burned coal and can be converted.
4. The greatest reduction in oil consumption can be effected by conversion of large plants burning in excess of 5000 gallons annually.
5. Some conversions of residential units are feasible but will take more time, material and labor.
6. Correct operation of heating systems and better inspection and maintenance will increase efficiency of existing plants.
   (a) Changes of operation include:
      (1) Lower maximum temperatures and accurate temperature control to avoid overheating.
      (2) Shorter operating hours and partial night shut-off.
      (3) Splitting of systems to permit different operating schedules for different portions of the building.
      (4) Cutting off rooms or upper floors of buildings.
   (b) Increase in efficiency to be obtained by:
      (1) Immediate adjustment and cleaning of equipment and periodic inspection of boilers, furnaces and controls.
      (2) Use of thermostats and other controls.
      (3) Reducing heat loss by application of insulation, storm sash, weatherstrips and closing of other openings.
      (4) Recirculation of air.
      (5) Proper firing methods for grade of fuel used.
      (6) Reduction of ventilation of bedrooms to provide only enough outside air to eliminate body odors.
7. Use of idle storage tanks at service stations would provide fuel oil reserve for winter and reduce strain on transportation facilities.
8. Campaigns to provide fuel stock pile for industrial and domestic users must be speeded up.
9. Use all agencies, press, radio, etc., to inform public of critical condition and urge fuel saving.
10. AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS' Research Laboratory can offer technical knowledge on comfort conditions desirable for efficiency and health.

Recommendations

On the basis of the findings outlined by the ASHVE War Service Committee, it is recommended that:

1. An accurate estimate be made of coal and fuel oil deliveries in the 17 eastern states and in Pacific Northwest states for a normal heating season, also amount of manufactured gas delivered for heating and figures on surplus or deficiency in these areas.
2. Obtain accurate estimate of probable supply of fuel oil (light, heavy and crude) for affected areas and check method of determining possible increased fuel oil demands in war plant areas.
3. Estimate the increased coal consumption necessary to meet 1942-43 heating demands of equipment converted from oil burning.
4. Determine the savings likely to result from the application progressively of:
   (a) Switch back to coal of large oil-burning plants which formerly burned coal.
   (b) Appeal to home owners for reduction in use of oil with appropriate instruction in means to be used.
   (c) Switch back of small oil burning units to coal.
   (d) Rationing of oil to all users unable to switch back, or not required to do so.
5. Check on rules for grates, controls and other materials governed by priority regulations where conversion is desirable.
6. Inform public promptly of facts in present fuel situation and urge positive action, through publicity during summer months so that enough fuel will be provided to adequately heat homes and protect health during the coming winter.
7. With cooperation of other organizations in heating field, arrange for ASHVE sponsorship and distribution of pamphlets and instructions regarding fuel conservation.

Mr. Fleisher then requested each of the men present to outline the work being done by their organizations and the preparations that have been made to meet a fuel shortage.

Mr. West, Secretary of the *American Gas Association,* gave some statistical data on peak load demands for residential heating and cooking equipment and commercial and industrial requirements and said that eastern gas companies were initiating campaigns for the conservation of gas for heating and also as a substitute fuel during the coming winter.

Allen Johnson, Director, *Anthracite Industries Laboratory,* told of the work that had been done during the past year and in preparing for conversion of oil fired heating equipment to anthracite burning. He said that field surveys showed that 25 per cent of the people having oil burning installations retained their grates and many of these plants could be converted to coal with equipment and only nominal labor cost. He said that new grates had been designed and were available for those who needed them and that the anthracite industry was prepared to take care of any load that might be thrust upon it and the only concern was whether this load could be spread out a little and not come at once.

In the general discussion, it was agreed that an average house owner realizes that there is an oil shortage but he is confused with what he reads in his newspapers, that a steel company is rushing a pipe line to completion, and that a shipbuilding company is producing a certain amount of oil tankers a day and

[Concluded on p. 526]

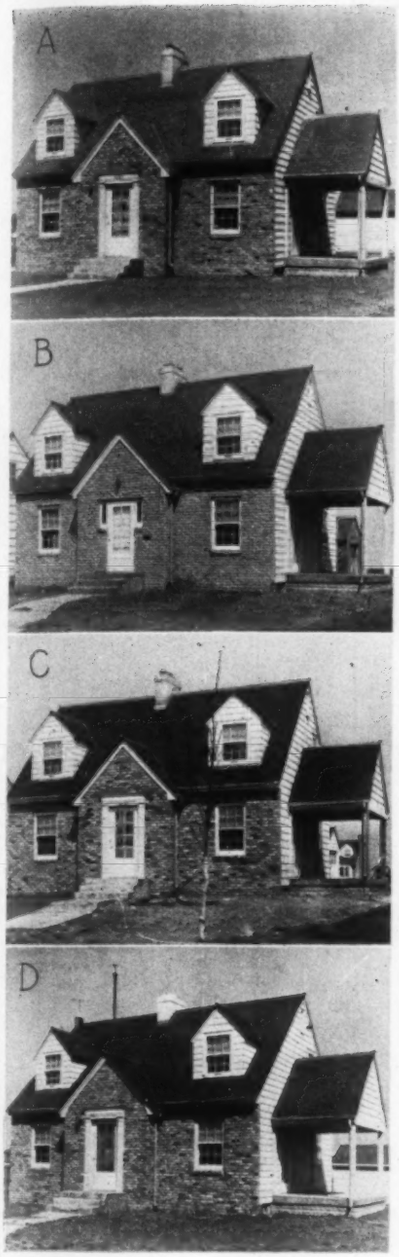


Fig. 1—Four test houses

Heat Loss Studies in Four Identical Buildings to Determine the Effect of Insulation

By D. B. Anderson,* St. Paul, Minn.

SUMMARY—Actual fuel savings effected by installing various thicknesses of insulation in four identical dwellings of typical construction were determined and compared with calculated results. Inside wall and glass surface temperatures were observed, together with the actual air temperature gradients from the floor to ceiling. In addition, data are included giving basement and attic air temperatures for the insulated and uninsulated structures.

Introduction

THE VALUE of insulation in residential construction (its ability to save fuel and increase comfort) is usually predetermined by heat loss calculations, taking into consideration the theoretical efficiency of the construction with and without insulation. Because there are so many avenues by which heat can escape from a dwelling (walls, windows, ceiling, floor, infiltration and complications of these involving sun and wind), all of which may vary with each different type of house, ordinary methods of calculating heat loss are not necessarily exact. Consequently, claims for the effectiveness of insulation, although they may be made in good faith, will vary considerably. To substantiate or correct the present methods of computation, some tests have been made in the field involving one or perhaps two houses. However, much field work is needed to provide information on this subject.

In order to further increase scientific knowledge, this paper presents the results found in four typical dwellings, each identical to the other except as to degree of insulation. These dwellings were exposed during the heating season to a wide range of weather conditions. It is hoped that these tests will be considered a link in the chain of scientific information which is continually being accumulated in an effort to increase the knowledge on this important subject.

*Manager, Sales Engineering Dept., Wood Conversion Co. ASSOCIATE MEMBER of ASHVE.
Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, St. Paul, Minn., June, 1942.

Object

The principal objects of this investigation were:

1. To determine the actual savings in fuel which can be effected by installing various thicknesses of insulation in identical dwellings of typical construction exposed to a wide range of weather conditions.
2. To compare the actual savings with calculated savings.
3. To determine the effect which various thicknesses of insulation have on:
   (*a*) wall and ceiling surface temperatures
   (*b*) temperature gradient from floor to ceiling
   (*c*) attic air temperature
   (*d*) basement temperature.

Description of Test Houses

Four houses were involved in this study designated as *A*, *B*, *C* and *D*,

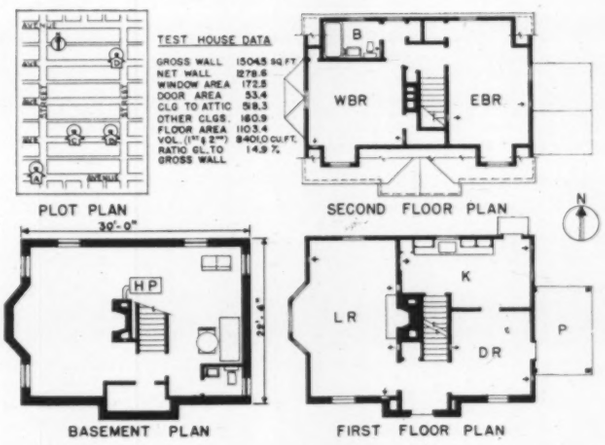


Fig. 2—Plot and floor plan of the four test houses

and shown in Fig. 1. All houses were located within an area of four city blocks, near the north city limits of St. Paul, Minn. In selecting the location for each of the test houses, the relative position of other buildings in the vicinity was considered in order that, as far as practicable, each test house would have equal exposure to sun and wind. The plot on which the houses were constructed was fairly level, and all houses were facing south.

The test houses were 1½-story structures of standard frame construction. With the exception of the degree of insulation, all houses were identical. The plan from which all houses were erected and dimensions of each are shown in Fig. 2. The wall section consisted of rough sand finish plaster on plaster board lath, 2x4-in. studs, wood sheathing, building paper, and wood shingles exposed 8 in. and applied in single course. On the first floor front wall only, brick veneer construction was used.

A shed dormer across the entire width of the second floor at the rear, together with the two dormers in front, provided a second floor area nearly as large as the first floor area. The ceiling section consisted of rough sand finish plaster on plaster board lath, applied directly to the underside of joists and rafters. The attic was not floored and a louvered opening in each gable provided means for venting the attic space. The roof section consisted of wood sheathing laid tight, asphalt felt paper with wood shingles exposed 5 in. to the weather. First floor construction consisted of 13/16 in. oak floor, building paper and 1 in. wood subfloor, applied to floor joists. Basement walls were of 12-in. concrete blocks, exposed approximately 12 in. above grade level, and the basement floor consisted of a 4-in. concrete slab.

All windows in the first and second floors were factory weatherstripped and equipped with storm sash and the basement windows were equipped with storm sash but not weatherstripped. Exterior doors were weatherstripped and equipped with storm doors. The finished ceiling heights were as follows: basement 6 ft 11 in. to underside of ceiling joists, first floor 8 ft 2 in., 2nd floor 7 ft 10 in.

Heat was provided by a forced warm-air oil burning furnace having a manufacturer's rated hourly output of 85,000 Btu and the oil burner was of the vaporizing type. The primary and secondary heating surfaces of the furnace totaled 42.5 sq ft. The heating plant was equipped with a centrifugal blower, belt driven by a two-speed motor. The furnace casing was provided with an inner liner spaced approximately 1 in. from the exterior casing.

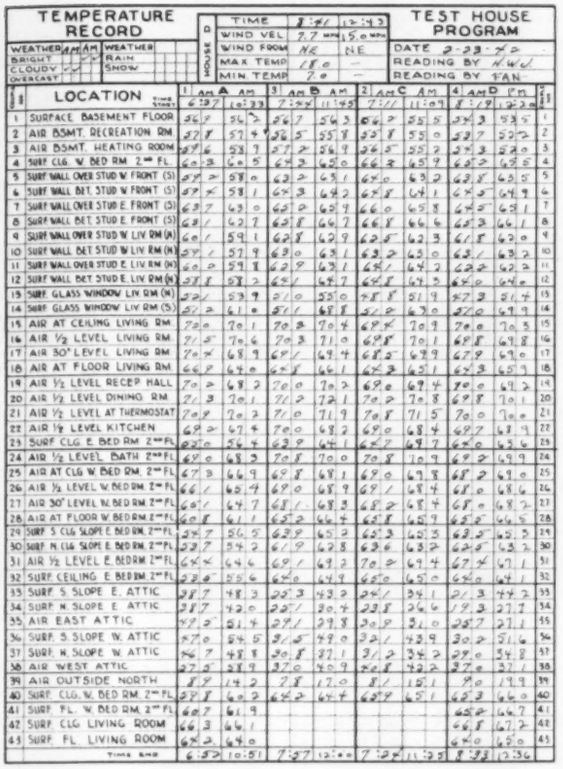
The plant was designed to operate automatically at three stages of fire, as determined by the room thermostat; namely, high, low and pilot. The high and low rates of oil input were determined by the position of two valves, which were actuated by electrically heated bimetal warp bars. The pilot oil flow was determined by a small metering pump, consisting of a low speed synchronous motor operating a dipper in an oil reservoir. The rate of oil flow at each stage of fire was adjustable. The rate of oil input as maintained in these tests was 0.80 gal per hour at high fire, 0.20 gal per hour at low fire, and 0.04 gal per hour at pilot flame.

On high fire the blower operated at high speed, on low fire and pilot flame the blower operated at low speed. Blower speed was controlled by a thermal relay, actuated by the thermostat circuit so as to switch the blower to full speed in proper sequence with high fire operation. In these tests the blower was set to deliver approximately 1000 cfm at high speed with a register velocity of approximately 375 fpm; at low speed the delivery was approximately 500 cfm with a register velocity of 175 fpm. Combustion air to the burner was supplied by a small centrifugal blower attached directly to the shaft of the main blower motor. An adjustable damper was provided in the duct leading from the combustion air blower to the burner which permitted the adjustment of the proper ratio of air to oil input at high fire. With the combustion air blower driven directly by the motor, its delivery was reduced automatically when the main blower operated on low speed. The design was such that an excess amount of air was supplied to the burner under this condition in order to avoid chimney condensation with the low stack temperature encountered during low fire operation. The location of the heating plant is shown in Fig. 2.

A draft regulator of the pressure balancing type was installed in the stack leading from heating plant to chimney. The duct design was identical in all houses and the warm-air supply and return registers were located as shown in Fig. 2. No humidification was provided. All registers were of the baseboard type, with air flow deflected 15 deg downward and the return air was filtered. The room thermostat was located on an inside wall of the dining room at a height of 49 in. above the floor, or one-half level, floor to ceiling.

House A was uninsulated; the three other identical houses were insulated with blanket insulation in exterior walls and second floor ceiling as follows: In *House B* the insulation was 0.9 in. thick, in *House C* the insulation was 1.7 in. thick, and in *House D* the insulation was 2.3 in. thick. The insulating mat consisted of felted wood fibres enclosed between continuous liners of asphalt saturated and coated paper. Insulation in *Houses C* and *D* was divided by intermediate liners, separating the total thickness into two individual layers; thus air circulation within the insulating material itself was reduced to a minimum. The conductivity k factor of the insulation was 0.25 Btu at a mean temperature of 70 F. The edges of each strip of insulation were stapled to the inside face of the framing members by means of a spacing flange, which automatically offset the insulation from the inside face of framing and provided an additional air space. The ends of each strip of insulation were fastened to plates or headers. In insulating the second floor ceiling, continuous strips of insulation were placed from the inside—between the rafters of the sloping ceiling, across the ceiling joists, and down the rafters of the opposite ceiling slope. Insulation was applied in accordance with manufacturer's specifications.

The test houses were constructed during the late summer of 1941; they were completed about October 1. Craftsmen employed were of average skill, and as a result, the workmanship on the completed jobs was representative of that found in modern residential construction.



TEMPERATURE RECORD

		TIME	7:45	12:45
WEATHER AM / PM	WEATHER	WIND VEL	7.7 MPH	15.0 MPH
BRIGHT	RAIN	WIND FROM	NE	NE
CLOUDY	SNOW	MAX TEMP	18.0	—
OVERCAST		MIN TEMP	7.0	—

TEST HOUSE PROGRAM

DATE 2-23-42

READING BY H.W.J.

READING BY F.A.N.

HOUSE	LOCATION	1 AM A AM	3 AM B AM	2 AM C AM	4 AM D PM	HOUSE
	TIME STARTED	6:37	10:33	7:44	11:45	7:11	11:09	8:19	12:20	
1	SURFACE BASEMENT FLOOR	36.9	56.2	56.7	56.3	56.2	55.5	55.3	55.3	1
2	AIR BSMT. RECREATION RM.	52.8	57.4	56.5	55.8	52.8	55.0	52.7	52.7	2
3	AIR BSMT. HEATING ROOM	58.6	58.3	57.2	56.9	56.5	55.2	54.3	54.0	3
4	SURF CLG. W BED RM. 2ND FL.	60.3	60.5	64.3	65.0	66.3	65.9	65.2	65.5	4
5	SURF WALL OVER STUD W FRONT (S)	59.2	58.0	63.2	63.1	64.0	63.2	63.8	63.5	5
6	SURF WALL BET. STUD W FRONT (S)	59.4	58.1	64.3	64.2	65.8	64.1	64.5	64.9	6
7	SURF WALL OVER STUD E FRONT (S)	63.7	63.0	66.0	66.9	66.0	65.8	64.5	65.1	7
8	SURF WALL BET. STUD E FRONT (S)	62.1	62.7	65.8	66.7	66.8	66.6	65.3	66.1	8
9	SURF WALL OVER STUD W LIV RM (N)	60.1	59.1	62.8	62.9	62.5	62.3	61.8	62.0	9
10	SURF WALL BET STUD W LIV RM (N)	59.1	57.9	63.0	63.1	63.2	63.0	63.1	63.2	10
11	SURF WALL OVER STUD E. LIV RM (N)	60.0	59.8	62.9	63.1	64.1	64.2	62.2	62.2	11
12	SURF WALL BET STUD E. LIV RM (N)	57.8	58.2	64.1	64.7	64.8	64.2	64.0	64.0	12
13	SURF GLASS WINDOW LIV RM (N)	52.1	53.9	51.0	55.0	48.8	51.9	47.3	51.4	13
14	SURF GLASS WINDOW LIV RM (S)	51.2	61.0	57.1	68.8	51.2	62.0	47.0	64.9	14
15	AIR AT CEILING LIVING RM.	70.0	70.1	70.3	70.4	69.4	70.9	70.0	70.3	15
16	AIR ½ LEVEL LIVING RM.	71.5	70.6	70.3	71.0	69.8	70.1	69.8	69.8	16
17	AIR 30" LEVEL LIVING RM.	70.4	68.9	69.1	69.4	68.2	68.9	67.9	69.0	17
18	AIR AT FLOOR LIVING RM.	66.9	64.0	66.8	66.1	64.3	65.1	64.3	65.3	18
19	AIR ½ LEVEL RECEP. HALL	70.2	68.2	70.0	70.2	69.0	69.4	70.0	69.2	19
20	AIR ½ LEVEL DINING RM.	71.3	70.1	71.2	72.1	70.2	70.8	69.8	70.1	20
21	AIR ½ LEVEL AT THERMOSTAT	70.8	70.2	71.0	71.9	70.8	71.5	70.0	70.0	21
22	AIR ½ LEVEL KITCHEN	69.2	67.4	70.0	68.2	69.0	68.4	69.7	68.9	22
23	SURF CLG. E. BED RM. 2ND FL.	62.0	56.4	63.8	64.1	65.7	64.7	64.0	63.6	23
24	AIR ½ LEVEL BATH 2ND FL.	69.0	68.3	70.8	70.0	70.8	70.9	69.2	69.9	24
25	AIR AT CLG W BED RM. 2ND FL.	67.3	66.9	69.8	68.1	69.0	69.8	68.2	69.0	25
26	AIR ½ LEVEL W BED RM. 2ND FL.	66.1	65.9	69.0	68.9	69.1	68.4	68.0	68.6	26
27	AIR 30" LEVEL W BED RM. 2ND FL.	64.1	64.7	68.1	68.3	68.2	68.4	68.0	68.2	27
28	AIR AT FLOOR W BED RM. 2ND FL.	60.8	61.1	65.2	66.4	65.8	65.9	65.2	66.5	28
29	SURF S CLG SLOPE E BED RM. 2ND FL.	54.7	56.9	63.9	65.2	65.3	65.3	63.5	65.3	29
30	SURF N CLG SLOPE E BED RM. 2ND FL.	53.7	54.2	61.9	62.8	63.6	63.7	62.6	63.2	30
31	AIR ½ LEVEL E BED RM. 2ND FL.	64.4	64.6	69.1	69.2	70.2	69.4	67.4	67.1	31
32	SURF CEILING E BED RM. 2ND FL.	53.0	55.6	64.0	64.9	65.0	65.0	64.0	64.1	32
33	SURF S SLOPE E ATTIC	38.7	48.3	25.3	43.2	24.1	34.1	21.3	44.2	33
34	SURF N SLOPE E ATTIC	38.7	42.0	25.1	30.4	23.8	26.6	19.3	22.7	34
35	AIR EAST ATTIC	42.2	51.4	29.1	39.8	30.9	31.0	28.7	27.1	35
36	SURF S SLOPE W ATTIC	47.0	54.5	31.5	49.0	32.1	43.9	30.2	51.4	36
37	SURF N SLOPE W ATTIC	44.7	48.8	30.8	37.1	31.2	34.2	29.0	34.8	37
38	AIR WEST ATTIC	37.5	38.9	32.0	40.9	34.8	32.2	32.0	32.1	38
39	AIR OUTSIDE NORTH	8.9	14.2	7.8	12.0	8.1	15.1	7.0	12.9	39
40	SURF CLG W BED RM. 2ND FL.	58.8	60.2	64.2	64.4	65.4	65.1	62.3	66.0	40
41	SURF FL W BED RM. 2ND FL.	60.7	61.9					65.2	66.7	41
42	SURF CLG LIVING ROOM	66.3	66.1					66.8	67.2	42
43	SURF FL LIVING ROOM	64.2	64.0					64.0	64.0	43
	TIME END	6:52	10:51	7:57	12:00	7:24	11:25	8:33	12:36	

FUEL RECORD TEST HOUSE PROGRAM

READING BY H.W.J. DATE 2-23-42

		A AM	B	C	D AM
TIME INDICATED IS EXACT TIME WHEN OIL IS ADDED TO WEIGHTING TANK		9:30			10:40
USE ONLY WHEN ADDING OIL TO SUPPLY TANK	WEIGHT INCREASED TO	304			375 3/8
	WEIGHT BEFORE FILLING	201 1/8			238 1/2
	WEIGHT OF OIL ADDED	102 1/2			137 3/8
	WEIGHT LAST REG. READING	209			242 3/8
	NEW "PREVIOUS WT" FOR RECORD BELOW	311 1/2			379 3/8

READING BY H.W.J. READING BY F.A.N. DATE 2-23-42

		1 AM A AM	3 AM B AM	2 AM C AM	4 AM D PM
TIME INDICATED IS EXACT TIME WHEN CLOCKS ARE READ AND WEIGHT OF OIL RECORDED		6:30	10:30	7:40	11:40	7:05	11:05	8:15	12:15
READING AT REG INTERVALS	PREVIOUS WEIGHT	209 1/2	311 1/2	349 3/8	341 3/8	283 3/8	276 3/8	249 3/8	379 3/8
	PRESENT WEIGHT	209	301 3/8	341 3/8	334 3/8	276 3/8	269 3/8	242 3/8	373 4
	CONSUMPTION PERIOD BEFORE	10 1/2	9 3/8	7 1/2	7	7 3/8	6 3/8	7	6 3/8
TIME OF STAGES OF HEAT PLANT OPERATION	CLOCK TIME	HRS MIN	HRS MIN	HRS MIN	HRS MIN	HRS MIN	HRS MIN	HRS MIN	HRS MIN
	HIGH + LOW FLAME	4 00	4 00	4 00	4 00	4 00	4 00	4 00	4 00
	HIGH FLAME	1 12	1 25	0 30	0 25	0 25	0 21	0 23	0 18
	LOW FLAME	2 48	2 55	3 30	3 33	3 35	3 39	3 37	3 42
	PILOT FLAME	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00
ELECT CURRENT CONSUMPTION KILOWATT HRS	PRESENT READING	438.1	438.9	374.3	374.9	378.0	378.6	377.2	377.7
	PREVIOUS READING	437.4	438.1	373.7	374.3	377.2	378.0	376.7	377.2
	TOTAL CONSUMP.	0.7	0.8	0.6	0.6	0.8	0.6	0.5	0.5
	MONTH TO DATE	94.8	95.6	71.5	72.1	71.5	72.1	71.4	71.9
INSIDE RELATIVE HUMIDITY	TIME OF READING	6:06	10:55	8:01	12:05	7:28	11:28	8:37	12:40
	DRY BULB TEMP.	69.5	69.5	71.0	70.0	70.0	70.0	69.0	69.5
	WET BULB TEMP.	49.5	49.0	50.5	49.0	50.0	49.0	49.0	49.0
	% RELATIVE HUMIDITY	18.5	16.5	18.5	15.0	19.0	15.0	18.0	16.5
STACK DATA READING BY S.D.K.	TIME OF READING	8:39 AM		1:10 PM		10:10 AM		5:45 PM	
	FLAME	HIGH LOW PILOT		HIGH LOW PILOT		HIGH LOW PILOT		HIGH LOW PILOT	
	ORSAT CO_2	10.2 3.9		10.0 4.0 0.4		10.4 3.7		10.2 3.8	
	ORSAT O_2	6.8 16.5		7.3 15.7 20.4		6.9 16.1		6.8 16.2	
	ORSAT CO	0 0		0 0 0		0 0		0 0	
	DRAFT IN .01 INCHES WATER	401 35-		40 35 2.5		40 35+		40 35	
	STACK TEMP. DEG. F.	495 290		460 249 115		470 295		450 250	
	GAL OIL CONSUMP. PER HOUR	.80 .20 .04		.80 .20 .04		.80 .20 .04		.80 .20 .04	

SUNSHINE HOURS ENDING →	AM 6	7	8	9	10	11	12	PM 1	2	3	4	5	6	7
			0.1	0.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.87	

Fig. 3—Example of temperature and fuel record sheets

The houses were unoccupied during the tests, for only in this way could the number of times they were entered be definitely controlled. To further regulate the amount of outside air admitted, a definite schedule of opening and closing windows was established as described later in this report. The houses were unfurnished. All first and second floor windows were equipped with shades, which were kept in half drawn position at all times.

Description of Testing Equipment

Temperatures were measured with copper-constantan thermocouples at 43 locations in each of the houses, as described on the temperature record sheet shown in Fig. 3. Readings were taken with a portable direct reading potentiometer as shown in Fig. 4, having a range of — 40 to 160 F. The thermocouples and instrument were checked against a standard thermometer. Essentially, the temperatures measured were air temperatures inside and outside, and surface temperatures on the inside of the construction. Air temperature in each room was measured by a thermocouple located at the center of the room at the one-half level, from floor to ceiling. In the living room and west bedroom additional thermocouples were provided at distances of 1 in. and 30 in. above the floor and 1 in. below the ceiling. Thermocouples at the 30 in. and one-half level positions were shielded with heavy paper cylinders 15 in. in diameter and 9 in. in height, covered on the outside with reflective foil.

All wall surface temperatures were measured with thermocouples located at the one-half level, from floor to ceiling. Temperatures were measured both midway between as well as directly over the studs, the exact position of all thermocouples with respect to framing members having been determined before interior finish was installed. Temperatures were also measured with thermocouples located as follows: Inside glass surface of the north and south windows of the living room (Fig. 8); surface of north and south ceiling slopes in east bedroom; flat ceiling surface in both bedrooms; floor and ceiling surfaces of the living room at *Houses A* and *D* only; floor surface in basement; floor surface of the west bedroom at *Houses A* and *D* only; air in attic at two positions, at distances of 7 ft from each gable (15 ft apart) and midway between second floor ceiling and roof ridge; inside surface of roof boards in attic space (two positions on each slope) and outside air 18 in. from the north wall and 13 ft above the grade level (shielded thermocouple). All thermocouples on the ceiling surfaces were located midway between the framing members.

Fuel oil consumption was determined by weight as shown in Fig. 5. The weighing tank which was connected to the feed line with a flexible hose was located on a platform scale. When required, oil was admitted to the weighing tank from the main supply tank. As a safety measure, two valves were provided in the supply line. When oil was being added to the weighing tank, the valve in the feed line from the tank to the heating plant was closed and the furnace requirements were taken from a reserve of oil held in the cup of the gage ordinarily used for checking the oil flow.

Self-starting electric clocks were installed to time the periods during which the heating plant operated at the various stages of fire. The current to these clocks was controlled

by mercury switches, actuated by the position of the oil supply valves. Meters were installed to measure the electric current consumption of the furnaces.

At *House D* only, the following equipment was installed: A maximum-minimum thermometer near the rear entrance on the north wall. An electric cup anemometer for measuring the wind velocity at a point 6 ft above the roof ridge. A weather vane for determining the wind direction is shown in Fig. 1.

At certain periods during the heating season the bedrooms were ventilated. The inside lower sash was opened to a fixed height of 6 in. and a metal covered slot 1½ in. x 8 in., located in the bottom rail of the storm sash, was opened. Thus the amount of window ventilation was uniformly the same for all houses.

Procedure

The tests were begun on October 10, 1941, and terminated on May 1, 1942. Thermostat settings were such that average air temperatures at the one-half level from floor to ceiling were as follows: first floor rooms, 70 F; second floor rooms, 68 F, except in uninsulated *House A* where, due to difficulty in maintaining a 68 F temperature, particularly during sub-zero weather, a temperature 2 deg less, or 66 F, was established as an average value for the second floor rooms of this house. Inability to maintain the same temperature in the second floor of the uninsulated house as in those insulated can probably be attributed to greater duct loss, especially in the second floor runs and greater over-all heat loss through the uninsulated wall and ceiling construction. The first floor rooms of *House A* were, however, maintained at an average temperature of 70 F. The same thermostat settings at all houses were maintained for both day and night operation.

Air infiltration was controlled as far as practicable. No one except those actually taking readings was admitted to the houses during the test. Front and side doors were not used; each of the four houses was entered through the rear door, which opened directly into the kitchen. The doors from the kitchen to the dining room and to basement were kept closed at all times. The name of the person entering, the date, the time of entrance and exit, and the purpose of each visit were recorded. During two periods, January 18 to February 3, inclusive, and February 15 to February 25, inclusive, readings were taken at 4-hour intervals. The complete schedule is given in Fig. 6. During the balance of the tests, readings were taken at 12-hour intervals beginning at 6:30 a.m. and 6:30 p.m. Example of record sheets on which the data obtained were recorded is shown in Fig. 3.

Each series of readings began at *House A* followed at 35-min. intervals by readings at *C*, *B* and *D*. The procedure at each was as outlined below:

1. Total time during which heating plant operated at stages of fire was determined from electric clocks.
2. Electric current consumption of heating plant was read from meters.
3. Fuel consumption was determined by weight (see Fig. 5).
4. Temperatures were read at central panel with portable potentiometer (see Fig. 4).
5. Wet- and dry-bulb temperatures, for determination of relative humidity, were obtained with hand-aspirated psychrometer.
6. During certain periods of the tests, bedrooms were ventilated at night. From October 10 to February 14, inclusive, two windows in each bedroom were opened to a fixed height as described previously. From February 15 to March 16, inclusive, no windows were opened. From March 17 to May 1, inclusive, both windows were opened. All changes in degree of ventilation were made at 6:30 p.m. and 6:30 a.m. When ventilation was provided, procedure during the 6:30 p.m. reading was as follows: Supply registers to both bedrooms were closed. Windows in both bedrooms were opened and the bedroom doors closed. At the 6:30 a.m. reading, this procedure was reversed — doors were opened, windows closed and registers opened. Changes in ventilation in all instances were made after temperature readings had been recorded.
7. Wind velocity was determined with electric cup anemometer.
8. Outside maximum and minimum temperatures were obtained by means of a maximum-minimum thermometer.
9. At frequent intervals the operation of the heating plant was thoroughly examined—this included analysis of the stack gases, measurement of stack temperature, draft, and check on flow of oil at each stage of fire. A system of switches was installed near the heating plant in the thermostat circuit to facilitate changing stage of fire during heating plant tests. The equipment required was Orsat apparatus, thermometer, draft gage and oil flow gage. The results of a typical test are shown in Fig. 3.

Discussion of Results

Selection of Temperature Data for Analysis of Results

In a study of this kind covering as many as 1,000 temperature readings every 24 hours during a heating season, a vast number of temperature readings are accumulated. It is obvious that some method must be devised by which the information can be analyzed from a portion of the data, much in the way that public opinion is analyzed on the basis of a sample group.

Considerable judgment must be used in the selection of these sample periods, in order that each will be representative of a normal heating cycle. For example, (*a*) outside temperature at the beginning and end of period should be approximately the same; (*b*) trend of outside temperature change (increasing or decreasing) should be in the same direction at beginning and end of period; (*c*) individual outside temperature readings should be well distributed through a wide range of temperatures in order to obtain a wide distribution of points for plotting curves; (*d*) amount of sunshine during each period should be representative of an average condition that might prevail during the heating season; (*e*) amount of sunshine at beginning and end of period should be equal.

It is obvious that an excessive number of temperature readings obtained, for instance, only under conditions of decreasing outside temperatures or less than normal sunshine, should be avoided since temperatures within the structure (inside surface temperatures, attic air temperatures, etc.) would be abnormally affected.

A group of the periods chosen for the detailed study is indicated in Fig. 6. Shown graphically, beginning at the bottom, are date of month, time, per cent of sunshine during each hour, schedule of readings, outside temperature, inside relative humidity based on outside absolute humidity, actual inside relative humidity and outside relative

Fig. 4—Temperature readings being taken with potentiometer at central panel

humidity at 6-hour intervals. Readings during these periods, as well as other periods not shown were used in preparing the curves in Figs. 8, 9, 10 and 11. With the exception of Fig. 11, which is plotted directly on the basis of actual temperature, all curves indicate the temperature *difference* which existed between room air at one-half level and the particular surface or air temperature under consideration.

Inside Wall Surface Temperatures

Illustrated in the lower portion of Fig. 8 is the temperature difference between living room air at one-half level and the inside north wall surface (between studs). For instance, the top curve of this group indicates that in the uninsulated *House A* with —10 F outside temperature, the wall surface temperature was approximately 15 deg less than the living room air. Of particular significance is the fact that the addition of insulation to the wall reduces the temperature difference between air and wall surface by nearly one-half under any outside temperature condition. For instance, at —10 F outside, the temperature difference between air and wall was reduced to approximately 9 deg with the first thickness (0.9 in.) of insulation in *House B*. Each additional increase in thickness of insulation effected less than 1 deg change in surface temperature.

Solar radiation indicated its effect on inside wall surface temperature. As a result, the temperature difference between living room air and south wall between studs (not shown in curves) was approximately 1 deg less at any outside temperature than that indicated for north wall of *Houses B, C* and *D* in Fig. 8.

In the uninsulated *House A*, the temperature difference between air and south wall was approximately 2 deg less than that of the north wall. In either of the houses (with or without insulation), the south wall temperature approached the room air temperature at about 60 F outside temperature.

In comparing the temperature conditions of the south and north walls of the living room, the difference in construction should be considered. The south wall was of brick veneer, the north wall entirely frame. The *U* values of the north and south walls were approximately equal—however, there was probably some variation in time lag due to difference in heat capacity of the materials used.

Calculated wall surface temperatures, based on an inside surface conductance of 1.65 and outside surface conductance of 4.5 (10 mph wind), are indicated in this group of curves by broken lines. It will be noted that in each case a difference exists between the calculated and actual values, the variation being from 3 F to 4 F at —10 F outside temperature and decreasing with rising outside temperature.

A similar variation between actual and theoretical values was found in a University of Minnesota study[1] and the results are indicated by points in Fig. 8. The writer concurs with the opinion of those investigators in that the inside surface conductance coefficients were

[1]Rowley, Algren and Lund, Engineering Experiment Station, Bulletin No. 18, University of Minnesota.

Fig. 5—Oil weighing tank, scale, and connections

probably much less than the commonly accepted 1.65 factor used in the calculations. This is believed to be due to the effect which the temperatures of other surfaces in the room have in influencing the heat transfer to the wall by radiation. While only actual and calculated values for the uninsulated wall are shown in Fig. 8, the University of Minnesota study shows approximately the same variation in the case of insulated walls.

Assuming constant values for surface conductance and over-all wall transmission with changing outside temperatures, the calculated temperature difference shown in Fig. 8 should be represented theoretically by a straight line. The flattening of the actual curves at the lower outside temperatures probably can be explained by greater air movement over the inside surface of the wall resulting from increased blower operation at lower outside temperatures.

The effect which other surfaces have on the actual wall surface tem-

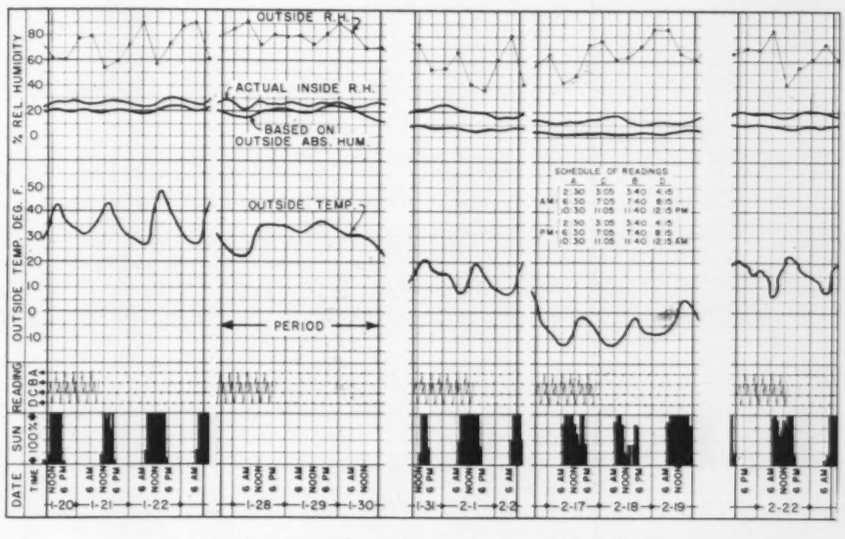


Fig. 6—Typical periods selected for detailed analysis

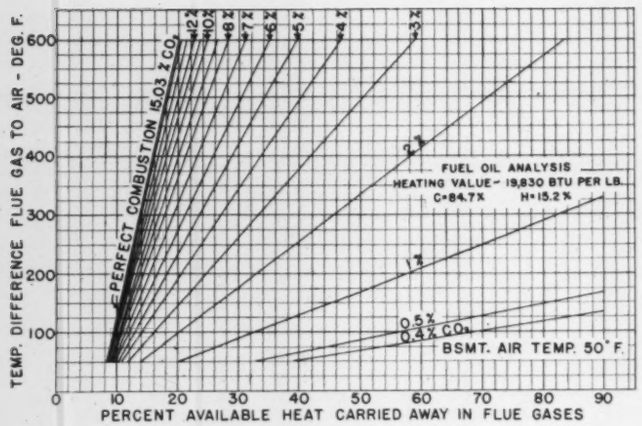


Fig. 7—Chart for determining heat loss in flue gases

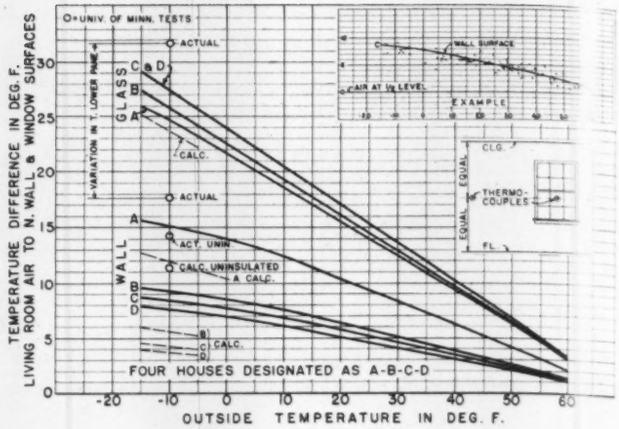


Fig. 8—Temperature difference—living room air to north wall and window surfaces

perature in these tests would probably not be as pronounced if the room contained furniture, since the surface temperature of the furnishings would approximate that of the room air. However, variables affecting the surface conductance, such as character of surface (color and roughness) and the amount of air movement over the surface, make it difficult to predict accurately wall surface temperatures using standard surface conductance coefficients.

It is well established that the temperatures of surfaces enclosing a space affect the comfort of the occupant. If the temperatures of the surfaces are sufficiently low, the increased radiation of body heat to the surface may produce an uncomfortable condition. Studies at the ASHVE Research Laboratory, as reported in THE ASHVE GUIDE,[2] indicate that the dry-bulb temperature in the room tested must be elevated 0.3 deg to compensate for a reduction of 1 deg in the average temperature of three side walls. Thus, if the three exterior walls in the living room of each test house were uniformly of the same heat resistance, with no greater loss at studs or windows, and if the floor and ceiling surface temperatures were identical in all houses, then at —10 F outside temperature we could assume that compared to *House B*, 1.8 deg (6 x 0.3 deg) higher air temperature would be required at *House A* for the same degree of comfort, to compensate for the 6 deg lower wall surface temperature at *House A*. See Fig. 8. Actually, however, in each of the test houses 17 per cent of the outside wall area of the living room is glass and at least 10 per cent studs, the surface temperatures of which we will assume are not affected by insulation. There remains a maximum of 73 per cent of the outside wall area, the temperature of which can be regulated by the addition of insulation. Therefore a change of 1 deg surface temperature *between studs* would actually be less than 1 deg in the over-all surface temperature of three walls, and would be offset by less than 0.3 deg change in air temperature. The same comparison between *Houses B* and *C*, and *C* and *D*, would indicate that the surface temperature difference of less than 1 deg, as measured between studs, would be compensated for by only a fraction of a degree change in air temperature.

These comparisons have been made at —10 F, only for the purpose of discussion. At higher outside temperatures, changes in wall surface temperature as indicated for the walls shown in Fig. 8, would be even less pronounced.

Complete calculation of the mean radiant temperature, on the basis of temperature of *all* surfaces enclosing a room, would be necessary in order to establish the relative air temperatures which would be required in the four houses for the same degree of comfort. Some increase in temperature undoubtedly would be required in the uninsu-

[2]HEATING VENTILATING AIR CONDITIONING GUIDE, 1942, p. 59.

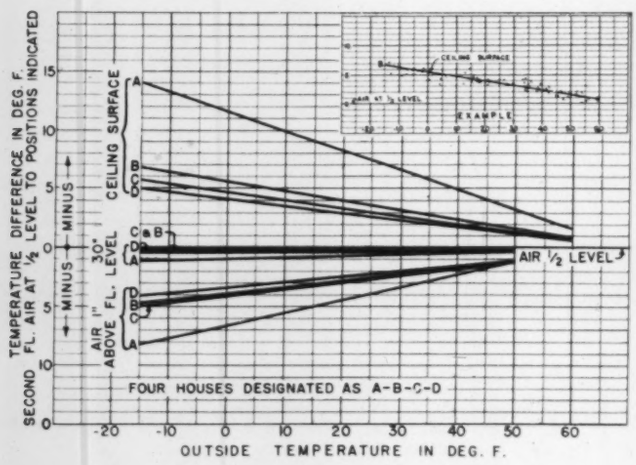

TEMPERATURE DIFFERENCE IN DEG. F.
SECOND FL. AIR AT ½ LEVEL TO POSITIONS INDICATED
MINUS
AIR 1" 30" ABOVE FL. LEVEL
CEILING SURFACE
AIR ½ LEVEL
FOUR HOUSES DESIGNATED AS A-B-C-D
OUTSIDE TEMPERATURE IN DEG. F.

Fig. 9—Temperature difference—second floor air at ½ level to air at 1 in. and 30 in. levels and to ceiling surface

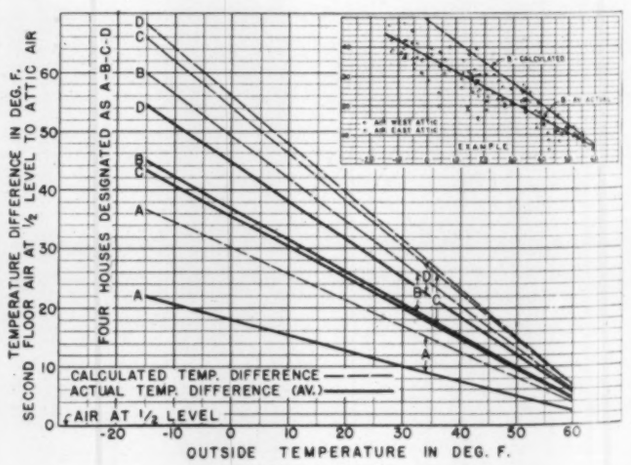

TEMPERATURE DIFFERENCE IN DEG. F.
SECOND FLOOR AIR AT ½ LEVEL TO ATTIC AIR
FOUR HOUSES DESIGNATED AS A-B-C-D
CALCULATED TEMP. DIFFERENCE
ACTUAL TEMP. DIFFERENCE (AV.)
AIR AT ½ LEVEL
OUTSIDE TEMPERATURE IN DEG. F.

Fig. 10—Actual and calculated temperature difference—second floor air at ½ level to attic air

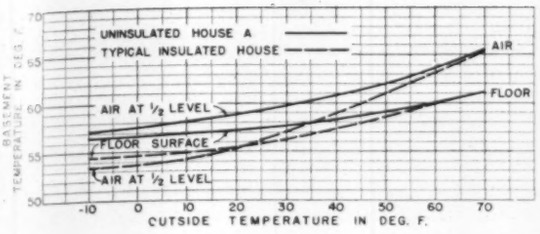


Fig. 11—Basement air and floor surface temperatures

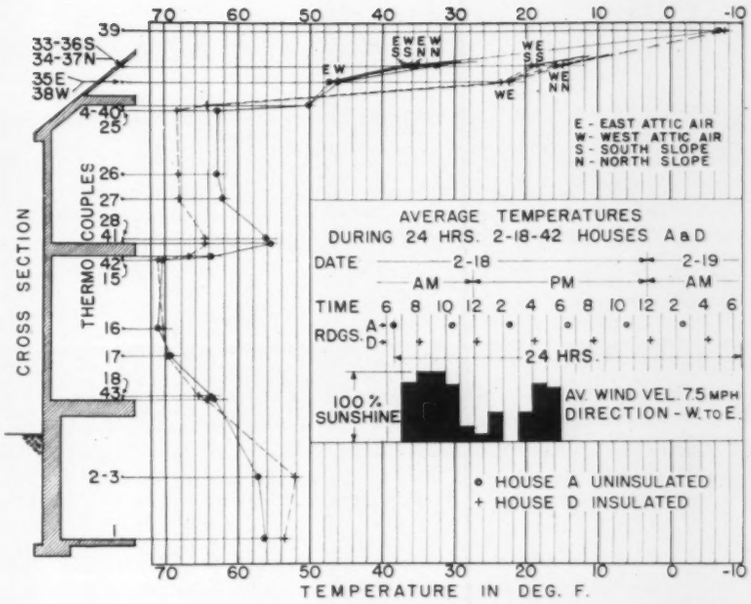

CROSS SECTION
THERMO COUPLES
AVERAGE TEMPERATURES
DURING 24 HRS. 2-18-42 HOUSES A & D
DATE 2-18 2-19
AM PM AM
TIME 6 8 10 12 2 4 6 8 10 12 2 4 6
RDGS. A D
24 HRS.
100 % SUNSHINE
AV. WIND VEL. 7.5 MPH
DIRECTION - W. TO E.
E - EAST ATTIC AIR
W - WEST ATTIC AIR
S - SOUTH SLOPE
N - NORTH SLOPE
• HOUSE A UNINSULATED
+ HOUSE D INSULATED
TEMPERATURE IN DEG. F.

Fig. 12—Temperatures at vertical section through two houses

lated *House A* in order to give the same degree of comfort as in *Houses B, C* and *D*. This differential, of course, would depend on the outside temperature. However, considering the temperature of every surface to which the occupant is exposed, including windows, partitions, ceiling, floor, furniture, wall hangings, etc., it is questionable if small variations in surface temperature between studs of outside wall areas of less than 1 deg, as indicated in comparison of *B* and *C*, and *C* and *D*, would affect noticeably the comfort of occupants, even though the same air temperature were maintained.

Wall surface temperatures directly over studs were analyzed. In the uninsulated *House A*, actual findings were compared with calculated values, determined on the basis of parallel heat flow. Calculation indicated that at —10 F outside temperature, the surface temperature over studs should be approximately 5½ deg higher than the surface between studs, due to insulating value of the stud itself. Actually the increase was between 1 deg and 2 deg. Probable explanation of this variation is that, due to high heat conductance of plaster board and plaster, heat flow occurred from the plaster directly over the stud into the colder adjacent areas. The tendency, therefore, was for the temperature over the stud to approach that of the area between the studs. The opposite condition was true in the insulated houses where the temperature over studs was 1 deg to 2 deg less than the temperature between studs, the greater difference occurring with increased thickness of insulation in *Houses C* and *D*.

Glass Surface Temperature

The temperature difference between living room air and glass surface of north windows is also shown in Fig. 8. It will be noted, for instance, that in *House A* the variation at —10 F outside is 24½ deg and that this temperature difference increases at *Houses B, C* and *D*. Since surface conductance, even with double glass windows, comprises a large part of the entire resistance of the window structure, part of this variation may be attributed to decreased surface conductance due to less air circulation over the glass surfaces in the insulated *Houses B, C* and *D*. It is probably also reasonable to assume that part of the difference may be attributed to normal variations encountered in measurement of glass surface temperature where construction of the sash and enclosing frame, air infiltration, air movement, etc., are influencing factors. In the same University of Minnesota investigation[3] it was found, as indicated by points in Fig. 8, that the inside surface temperature of glass in the lower pane of a double-hung window (with storm sash), exposed to —10 F outside temperature, varied 14 deg from top to bottom. In the test houses, the lower pane was divided into six parts with a muntin arrangement as shown in insert, Fig. 8. It is possible that the extending sill, jamb, and muntins further disturbed the air movement across the glass in such a manner as to contribute to the differences between measured values.

[3]Loc. Cit. Note 1.

Second Floor Air and Ceiling Surface Temperatures

The difference in temperature between second floor air at one-half level and air 1 in. and 30 in. above the floor level and the ceiling surface, is shown in Fig. 9. The temperatures at 1 in. and 30 in. levels are important because the occupant's comfort depends largely on conditions in the lower portion of the room. For instance, in uninsulated *House A* at —10 F outside, nearly 8 deg temperature difference existed between the air at one-half level and 1 in. above the floor. In the insulated *Houses B, C* and *D*, this temperature difference was 4 deg to 5 deg, or a reduction of approximately ½. Since the temperature 1 in. above the floor showed only a 1 deg variation between *Houses B, C* and *D*, it is evident that the different thicknesses of insulation as used in these tests, and applied to exposed walls and ceiling, have little effect on the air temperature at this level. Other studies made at *Houses A* and *D*, not shown in these curves, indicated that the temperature of the floor surface itself agreed very closely with that of the air 1 in. above the floor.

At —10 F outside, the air at the 30-in. level in uninsulated *House A* was approximately 1 deg less than

air at the one-half level. In the instance of insulated *Houses B, C* and *D,* however, the variation was not appreciable, being less than ½ deg with any thickness of insulation. The second floor ceiling surface in the uninsulated *House A* at —10 F outside, was approximately 13 deg lower than the temperature of the air at one-half level. With the addition of insulation, this temperature difference was reduced by approximately ½.

Attic Air Temperatures

The temperature difference between air at one-half level of the second floor rooms and attic air is shown in Fig. 10. The solid lines indicate the average variation found by test with attic space vented with a louver in each gable having a net open area of 0.47 sq in. per square foot of flat ceiling area or 0.23 sq in. per square foot of total ceiling area, including the sloped portions. The broken lines indicate the variation as determined by calculation, using combined coefficients and assuming no attic ventilation. It is interesting to note that the average temperature drop through the ceiling construction, even with the attic vented, is less than that which would be indicated by a calculated attic temperature with no ventilation. This is consistent with the statement in the GUIDE that ordinary venting during the winter season may have only a minor effect on attic temperature.[4] It is assumed sometimes that venting the attic space would lower the attic temperature to that of the outside temperature. The findings here do not agree with that assumption. Higher attic temperature than indicated by calculation may be attributed to one or a combination of the following factors: (*a*) During the day, direct solar and scattered sky radiation even on cloudy days when a certain amount of radiation pierces the clouds. (*b*) During the night, some tendency for the construction, due to its heat capacity, to retain heat gained during the day. (*c*) Heat given up by the chimney.

Inconsistency as compared to calculated values also may be due to lack of exactness in methods of calculating attic air temperature, since the method is based on assumptions which may or may not be satisfied in individual cases.

In the calculation of fuel savings which can be effected with insulation, the portion of heat loss which is assumed to take place through ceiling and roof construction affects the over-all results appreciably. This variable, in combination with others which are encountered in the calculation of heat loss, is a contributing factor which results in many divergent claims made regarding the effectiveness of insulation. In many instances the calculated per cent savings is not in agreement with actual results. These tests indicate that further experimental work on heat loss through roof constructions involving varying amounts of ventilation, different types of roof construction, etc., would be desirable, in order that more accurate methods of calculating heat losses through this portion of the structure might be developed.

Basement Temperatures

Actual basement air and floor temperatures are shown in Fig. 11. Comparison is drawn between temperatures at uninsulated *House A* and a typical insulated house. The temperatures at *House A* are indicated by solid lines. Conditions in the insulated house are indicated by broken lines. The only heat supplied to the basement was that provided by normal loss from heating plant and ducts. Comparing air temperatures only, it will be noted that at —10 F outside, the air temperature in the basement of the uninsulated house was approximately 4 deg higher than that in a typical insulated house. This can be explained by the fact that the heating plant in the uninsulated house operates more continuously and the resulting heat loss from the equipment is sufficient to increase the basement air temperature. Comparison of the floor surface temperatures at —10 F indicates that while the temperature of the floor surface in the uninsulated house is less than the air temperature, the reverse condition is true in the insulated house. It would seem from these findings that the heat from the heating equipment in the insulated house is insufficient to supply the heat loss from the basement at these lower temperatures, and as a result the air temperature drops below that of the floor temperature. The ground temperature and normal lag between temperature of air and concrete floor, due to heat capacity of the latter, prevented the floor surface temperature from following the drop in air temperature during the relatively short periods of sub-zero temperature. As the outside temperature increased to 70 F the air and floor temperatures in both insulated and uninsulated houses ap-

[4] HEATING VENTILATING AIR CONDITIONING GUIDE, 1942, p. 112.

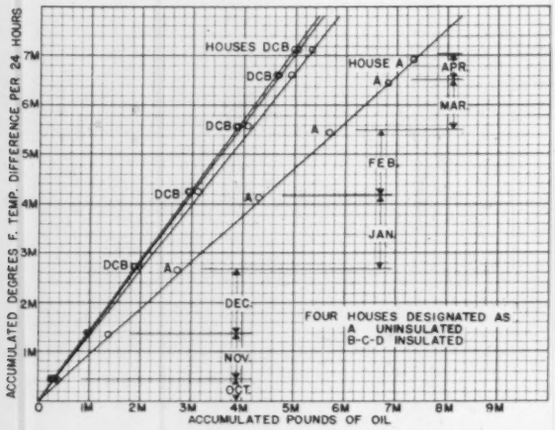


Fig. 13—Fuel consumption *vs.* temperature difference per 24 hours

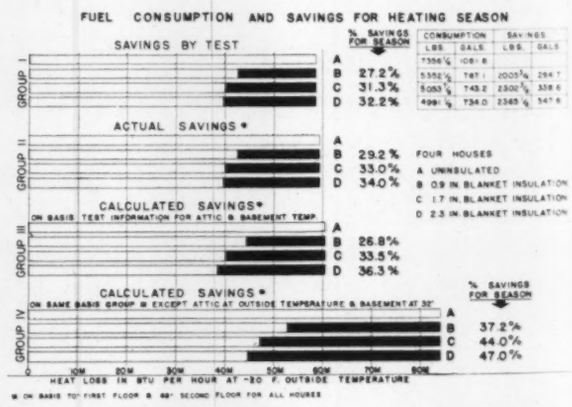

FUEL CONSUMPTION AND SAVINGS FOR HEATING SEASON
SAVINGS BY TEST
ACTUAL SAVINGS *
CALCULATED SAVINGS*
CALCULATED SAVINGS *
HEAT LOSS IN BTU PER HOUR AT -20 F. OUTSIDE TEMPERATURE
FOUR HOUSES
A UNINSULATED
B 0.9 IN. BLANKET INSULATION
C 1.7 IN. BLANKET INSULATION
D 2.3 IN. BLANKET INSULATION

Fig. 14—Actual and calculated fuel consumption and savings for heating season

proached 65 F and 61 F, respectively.

Temperature at Vertical Section in Houses

Indicated in Fig. 12 are average temperatures during a specific 24-hour period, plotted to show air and surface temperatures at the vertical section through *Houses A* and *D*. Reference to the vertical section at left indicates to approximate scale the relative position at which temperatures were measured, and the average temperature reading is indicated on the horizontal scale, reading from 70 F at left to —10 F at right. The lines between points are merely connecting lines for easier reference to plotted points and are not intended to show the complete gradient through the structure. Each plotted point is the average of 6 readings, taken at 4-hour intervals during a 24-hour period. Of particular interest is (*a*) the lower floor and ceiling surface temperature in the first floor of uninsulated *House A;* (*b*) the temperature drop through the first floor ceiling, due to normal temperature gradient on first and second floors and the lower air temperature in the second floor rooms; (*c*) the small temperature drop through the uninsulated second floor ceiling construction and the corresponding large temperature drop through the insulated ceiling construction; (*d*) temperatures of the inside surface of the north and south slopes of the roof in both the east and west ends of the attic—the temperatures on the south slope being higher, due to solar effect; (*e*) the relatively high vented attic air temperature with reference to outside air in both insulated and uninsulated houses.

Heating Plant Efficiency

A typical flue gas analysis is recorded on data sheet in Fig. 3. In order to translate these results into efficiency of heating plant, the chart shown in Fig. 7 was prepared. The data for this chart were calculated on the basis of the ultimate analysis of the fuel oil used. Comparison of the results from each test made during the heating season with this chart indicated no appreciable variation in percentage of heat loss. From the results of the entire series of tests, certain average values for stack temperature and CO_2 were determined as follows: high fire, 470 F temperature with 10.4 per cent CO_2; low fire, 250 F temperature with 3.8 per cent CO_2. Reference to the efficiency chart indicates a stack loss of 19 per cent and 21 per cent respectively under these conditions of temperature and CO_2, with 50 F basement air. Radiation and unaccounted for losses must be added—from inspection these are assumed to be approximately 5 per cent at high fire and 3 per cent at low fire. Applying these corrections, the over-all heat loss becomes 24 per cent on either stage of fire. It is assumed, therefore, that for all practical purposes the over-all efficiency on both high and low stages of fire is 76 per cent. The calorific value of the fuel oil used was 19,830 Btu per pound; therefore on the basis of 76 per cent efficiency, the useful Btu per pound was 15,070.

Actual and Calculated Fuel Consumption

Shown in Fig. 13 is the actual accumulated fuel consumption during the heating season as plotted against the total degrees temperature difference per 24 hours. For any one day there exists as many degrees temperature difference as there are degrees Fahrenheit difference between the average outside temperature for the day and the average inside temperature. It was assumed, in compiling the information shown in Fig. 13, that the average temperature (first and second floors) maintained was 68 F in the uninsulated house and 69 F in insulated *Houses B, C* and *D*. The variance is due to a 2 deg lower average second floor temperature in *House A* than in *B, C* and *D*, with first floor in all houses 70 F. The points nearest the upper edge of the chart are located by plotting the total number of degrees temperature difference per 24 hours, accumulated from October 10, 1941, to May 1, 1942, against the total pounds of fuel consumed during the same period. The reference lines shown connect these particular points with the zero reference at the lower left without regard to the intermediate points. Based on this information, the average pounds of fuel oil consumed per degree temperature difference per 24 hours can be determined.

The fuel consumption during the period of test is indicated in Group I of Fig. 14. The consumption and savings in pounds and gallons of oil and the per cent savings accomplished with the various thicknesses of insulation are shown in table form. Of particular significance are the fuel savings; namely, 27.2 per cent for insulated *House B*, 31.3 per cent for *House C*, and 32.2 per cent for *House D*. The gallons of oil saved are 294.7, 338.6 and 347.8 respectively. The scale at the bottom of Fig. 14 indicates the heat loss in Btu per hour at —20 F outside temperature. The heat loss under conditions of actual test was determined on the basis of (1) pounds of fuel consumed per degree temperature difference per 24 hours as obtained from Fig. 13, (2) useful Btu per pound of fuel, and (3) difference between average inside air temperature and outside air temperature.

The actual fuel savings with temperature in second floor *House A* maintained at 68 F, are shown in Group II. The fuel savings for *Houses B, C* and *D* are 29.2 per cent, 33.0 per cent and 34.0 per cent, respectively. The percentage savings in this instance are figured on the basis of the information taken from Fig. 13.

The calculated heat loss and savings in fuel, based on temperature information for basement space, attic, etc., as gained from this study, are shown in Group III. In this calculation, air infiltration is based on one volume change per hour, outside wind velocity 10 mph (assumed to be average for the Test House location), inside first floor temperature 70 F, second floor temperature 68 F at all houses, with an outside temperature of —20 F. The fuel savings for *Houses B, C* and *D* are 26.8 per cent, 33.5 per cent and 36.3 per cent respectively. The calculated heat loss and savings in fuel, assuming *outside temperature* in attic space and 32 F in basement, are shown in Group IV. In all other respects the basis for calculation was the same as for Group III.

In attempting to correlate calculated and actual heat losses, it is realized that there are many variables which affect the final results. In summarizing the information in

Fig. 14, of particular significance, however, are the larger savings effected with the first increment of insulation and that subsequent thicknesses are relatively less effective. For instance, referring to Group II, the insulation in *House B* (0.9 in. thick) saves 29.2 per cent fuel during the heating season, the insulation in *House C* (1.7 in. thick) saves 33.0 per cent fuel, and the insulation in *House D* (2.3 in. thick) saves 34.0 per cent fuel.

The greatest spread between percentage savings with the least and greatest thickness of insulation used in these tests is actually 34.0 per cent — 29.2 per cent, or 4.8 per cent. Calculations based on test information indicated that this variation would be approximately 36.3 per cent — 26.8 per cent, or 9.5 per cent. A probable explanation for this discrepancy is that insulation used in *House B* is of a thickness which approximates the heat resistance of the framing members; therefore studs, etc., contribute effectively toward the reduction in overall heat loss. As the thickness of insulation increases, the loss through framing, plates, sills, sash weight boxes, diagonal bracing, fire stops, etc., becomes greater than the loss through the insulated portion of the stud space, and the effect of many of these factors in reduction of overall performance cannot be applied in calculations. The lower the theoretical coefficient the greater will be this percentage of error, due to greater heat loss through framing members and construction defects. Variations of this kind between theoretical and actual performance, as the insulation exceeds the insulating value of the studs, have caused many engineers to arbitrarily adopt a minimum *U* value of 0.10.

The calculated heat loss and percentage fuel savings indicated in Group IV, Fig. 14, are shown merely to indicate the importance of proper use of attic temperature and basement heat loss information. All other factors used in calculating information for Group IV are identical with Group III except for the use of outside temperature in attic and 32 F in basement, rather than the temperatures as determined by this test.

Conclusions

Four test houses exposed to a wide range of weather conditions, were involved in this study. The construction of each was identical except as to the degree of insulation. *House A* was uninsulated; *Houses B, C* and *D* were insulated with blanket insulation in thicknesses of 0.9 in., 1.7 in., and 2.3 in. respectively. Following is a summary of the results obtained:

1. The installation of blanket insulation in *Houses B, C* and *D* effected a saving in fuel consumption by test of 27.2 per cent, 31.3 per cent and 32.2 per cent, respectively. With equal second floor temperatures in all houses, the savings become 29.2 per cent, 33.0 per cent and 34.0 per cent, respectively. Of particular significance is the relatively large savings in fuel with the first increment of insulation at *House B;* namely, 294.7 gal. Increasing the thickness of insulation in *Houses C* and *D,* increased the annual savings in fuel 43.9 and 9.2 gal, respectively.

2. The calculated heat loss based on information regarding temperature of attic space, basement, etc., as determined in this test, indicated reasonable agreement with the actual value. The savings as calculated, employing these refinements, were 26.8 per cent, 33.5 per cent and 36.3 per cent, respectively.

3. With attic temperature assumed to be the outside temperature and basement assumed to be 32 F, the calculated heat loss was increased approximately one-third and the calculated savings effected with insulation were 37.2 per cent, 44.0 per cent and 47.0 per cent, respectively.

4. At −10 F outside temperature, the inside surface temperature of north exposed uninsulated walls (between studs) was approximately 15 deg below that of the inside air. Insulation decreased the air to surface difference by approximately one-half. The variation in surface temperature between each of the thicknesses of insulation was less than 1 deg.

5. At −10 F outside temperature, the inside surface temperature of the second floor uninsulated ceiling was approximately 13 deg below that of the inside air at one-half level. The insulation decreased this temperature difference approximately one-half—the variation in surface temperature between each of the thicknesses of insulation being less than 1 deg.

6. At −10 F outside temperature, the inside surface temperature of glass in north windows with storm sash was approximately 24½ deg to 27½ deg below that of the inside air.

7. In the second floor rooms with −10 F outside temperature, the temperature difference between air 1 in. above the floor and one-half level was approximately 8 F without insulation. In the insulated houses this difference was reduced approximately one-half. The temperature change effected at this level with different thicknesses of insulation was not appreciable. The temperature difference between the one-half level and 30 in. above the floor was approximately 1 deg with no insulation and less than ½ deg with insulation.

8. The difference in temperature between air at one-half level in the second floor rooms and the average temperature of the vented attic, was less than the difference between second floor air and attic air calculated by combined coefficient method, assuming no attic ventilation.

9. At −10 F outside temperature, the basement air was approximately 57 F in the uninsulated house. In the insulated houses the air temperature was approximately 4 deg less, or 53 F. As the outside temperature increased, both of these temperatures approached 65 F. No heat other than normal loss from heating equipment was provided in the basement.

Acknowledgment

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TELLERS' REPORT

The vote on the Standard Method of Test for Thermal Conductivity of Materials by Means of the Guarded Hot Plate (*tentative*) has been reported by the Tellers, Charles R. Hiers, Joe Wheeler, Jr., and Harry H. Bond, as follows: Total ballots cast 339; legal ballots 329; in favor of Code 318; against Code 11.

See Discussion on page 516

Air Conditioning of Blackout Plants

By Walter A. Grant,* Philadelphia, Pa.

SUMMARY—**The huge expansion of industrial plants, due to the war, has introduced air conditioning in more kinds of plants and in more different processes than ever before. Outside of the problems arising from the enormous size of the buildings, the engineering design methods follow well established application practises. With speed the paramount factor in the armament program, air conditioning has been classed as an essential industry for reducing product rejects; maintaining spoilage to a minimum; and keeping every man and machine at the peak of production efficiency.**

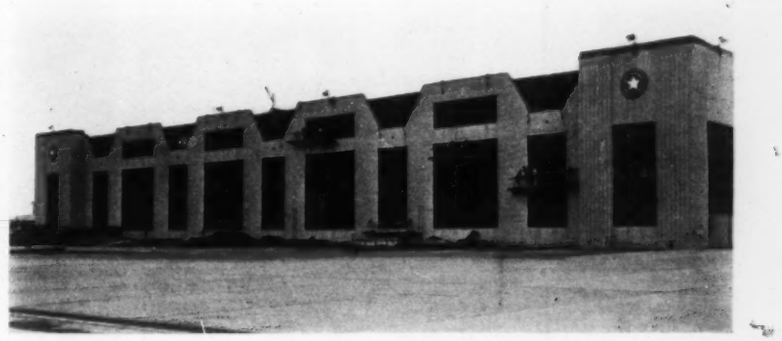

Fig. 1—Blackout curtains being applied to plant windows

OUTSTANDING in the vitally important prosecution of our war effort is the gigantic expansion in industrial building which has occurred in the last two years. Despite the speed of construction, suitability to the task to be performed has been the guiding consideration in the design of these structures. Most stirring to the public imagination perhaps has been the construction of the enormous factories for the production of aircraft and aircraft engines.

Some confusion exists as to what constitutes a blackout plant. Broadly speaking, every manufacturing plant whether built with windows (Fig. 1) or windowless can be blacked out when the necessary precautions have been incorporated either before or after the building has been completed. Supplementing the term *blackout* therefore, it is desirable to draw the distinction between factories which have windows and those which do not.

The processes for which these many plants have been built are almost infinite in number, but it is a fact that, in general, the technique of designing the heating or the air conditioning is relatively independent of them. The process may, and usually does, determine whether simple heating, or partial or complete air conditioning is to be used. Beyond that, the treatment is largely a function of the building—its shape, size, interior divisions, exterior exposures, structural influences and interferences, population distribution, and other job conditions.

None of these considerations are new or unique, and the technique of heating or air conditioning a factory building is probably the simplest and least troublesome application of the art that the industry has had occasion to face, and it has faced it for a good many years. The really only new element that has entered the picture is the element of *size*, and this will be recognized as the same element which has captivated popular interest and wonder in the aircraft engine and assembly plants. These large special-purpose factories have been built for the mass production of one particular instrument of warfare, and in more ways than one typify the resourcefulness and resolution of the technical brains behind our war effort. The comparison between aircraft assembly and aircraft engine plants is useful and enlightening, since their requirements are quite different. Furthermore, as was previously implied, in general the solution of these requirements and the conclusions therefrom are applicable to almost all modern industrial buildings.

Heating, Ventilating and Air Conditioning

A comprehensive task confronts the heating and ventilating engineer. The complete treatment of one of these plants involves most and frequently all of the following functions:

1. Adequate treatment of the factory working spaces is perhaps the largest single item. Whether heating with natural or forced ventilation, or evaporative cooling, or all of the complete air conditioning functions—this part of the project usually involves treatment for the largest number of employees, requires the greatest expenditure of money in equipment, and uses the most fuel and power to operate. Atmospheric conditions require control in some cases for the benefit of the product, in others for the promotion of human efficiency.
2. Production of comfortable conditions for the office employees is of course necessary. Frequently either a separate office building is part of the project, or a portion of the building is segregated for the management, technical and clerical staffs.
3. Most plants have special-purpose rooms, devoted to testing, precision operations, or storage requiring special conditions of indoor weather.
4. Other miscellaneous spaces such as dead storage for materials, receiving platforms, etc. require simple heating only.
5. Where thousands of people are to be fed, there is always the application of refrigeration and air conditioning for the preservation of food.
6. Certain localized areas such as heat treating rooms, or manufacturing spaces where fuel is burned in large quantities require special precautions to maintain at least tolerable working conditions.
7. There is always a fairly extensive ventilation and exhaust requirement for kitchens, toilets and locker rooms.
8. Finally, special exhaust systems are

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frequently required for the collection of fumes in pickling, electro-plating, painting, wet cleaning, anodizing operations, and the removal of dust in sandblasting and grinding.

Most of these problems are solved in the conventional manner which has developed and progressed with the art during the last few years. The aspect which has received the focus of most attention is the treatment of the main manufacturing and assembly areas, and it is toward this aspect that this discussion is devoted.

Main Factory Work Spaces

In the modern aircraft assembly and engine plant, these spaces have certain distinguishing characteristics, some of which are relatively new. In the first place the dimensions in all directions exceed anything which has been contemplated in the past. Some of these plants are as long as 4,000 ft in a single building with widths of 500 ft. The engine plants normally have clear ceiling heights under the trusses of from 14 ft to 18 ft, which will be recognized as conventional factory practise. Some of the assembly factories on the other hand run all the way to 45 ft clear height. The span between columns may be very great, and some plants have been built with spans of 300 ft. Partitions are usually few, and when used are generally for the segregation of heavy heat loads from furnaces, paint spraying operations, and the like.

Windowless Building

There is no hard and fast answer to the question: when should a windowless building be used?—but a general trend is apparent. While it is not necessary to air condition a windowless building, a minimum prerequisite is an adequate system of mechanical ventilation to provide the equivalent of movable sash in a building with sawtooth or monitors. But, from the opposite point of view, where air conditioning is considered *necessary*, the entire operation is *simplified* by making the building windowless. The load is drastically reduced, window condensation is avoided, and the problem of good air distribution, particularly with regard to heating, is eased considerably.

The windowless building is more costly to build. The cost does not occur in the structure since the cost of building walls is approximately that of the windows which are replaced. The additional cost includes air conditioning and a number of other items which good practise usually indicates in a windowless building, such as sound insulation on ceiling and walls to reduce internal noise. Against the increase in investment is balanced a cut in the heating cost alone to about one-third of that for a building with windows, plus an improvement in health and efficiency which, while difficult to evaluate, has been proved to be real and important. The opportunity to save fuel in winter, in view of shortages, should not be overlooked.

When Should a Plant Be Completely Air Conditioned?

There are only two major factors to be considered in answering that question. The first is related to improvement in the product, the second involves the effect upon the human being. Where high precision work is being performed, there is almost invariably a rigid requirement for the maintenance of tolerances and this implies a uniform temperature year in and year out. Coupled with this requirement is the paramount importance of excluding dirt, which is almost impossible in a building with windows and without air conditioning. Frequently also perspiration must be avoided in the handling of the precision parts. Where precision manufacturing is required, therefore, air conditioning is practically essential, and can definitely be evaluated in lower scrap losses and higher production.

The improvement in human efficiency is a real factor but somewhat intangible because of the difficulty in measuring it. The principal result is the lessening of fatigue, with the accompanying benefits, the reduction of spoilage and accidents. Of real importance also is the reduction in absences from sickness, particularly due to respiratory infections.

Some plant processes generate quantities of heat which produce working conditions that are practically intolerable. While data are not as yet sufficient to prove that such conditions are actually a health hazard, the reduction in the output and productivity of labor is beyond question.

In comparing the two types of aircraft projects, assembly plants and engine plants, it can be concluded that engine plants (Fig. 2) usually require complete air conditioning because of the product. It is a fact that the major engine plants are completely air conditioned throughout—Ford, Packard, Wright, Allison and Jacobs. The precision requirement, except in special departments, is not generally present in assembly plants, and practise is about evenly divided as to the importance of providing complete air conditioning for the promotion of human efficiency. Representative of plants which use simple heating and open the windows in summer are Bell, Ford Bomber, Martin, Boeing and the first Consolidated plant. Aircraft assembly

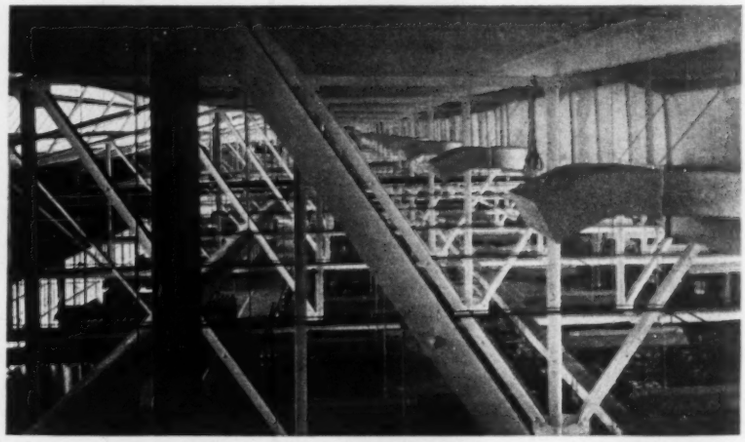


Fig. 2—A view of part of the duct work used for distributing conditioned air through a factory.

Table 1—Comparative Comfort Produced by Ventilation, Evaporative Cooling and Complete Summer Air Conditioning

Difference Between Room and Supply Air Temperature (Δt)	[a]Condition	Outside Conditions (F)				Inside Conditions (F)			
		DB	WB	Per Cent RH	ET	DB	WB	Per Cent RH	ET
		Simple Ventilation							
5 F	*A*	95	78	48	84.5	100	79.3	41	86.5
	B	90	70	37	79.4	95	71.5	32	81.5
	C	82	78	84	79.6	87	79.3	72	82.0
10 F	*A*	95	78	48	84.5	105	80.4	36	88.5
	B	90	70	37	79.4	100	72.9	28	83.5
	C	82	78	84	79.6	92	80.4	62	84.5
		Evaporative Cooling (*with 95 Per cent Saturation efficiency*)							
10 F	*A*	95	78	48	84.5	89	80.4	70	83.5
	B	90	70	37	79.4	81	72.9	68.5	76.5
	C	82	78	84	79.6	88.2	80.4	72	83.5
15 F	*A*	95	78	48	84.5	94	81.7	59.5	85.5
	B	90	70	37	79.4	86	74.2	58	79.5
	C	82	78	84	79.6	93.2	81.7	61.5	85.5
		Air Conditioning With Dehumidification							
Any	*A*	95	78	48	84.5	80	66.7	50	74
	B	90	70	37	79.4	80	66.7	50	74
	C	82	78	84	79.6	80	66.7	50	74

[a]Condition *A* is a design maximum; *B* is a typical sunny dry day; *C* a typical cloudy muggy day.

plants which have been completely air conditioned include Douglas, Grumman, North American and the two latest Consolidated factories.

Methods of Heating, Ventilating and Air Conditioning

Basically there are five possible methods which can be effectively used for the treatment of these plants depending on whether they are to be simply heated or fully conditioned:

1. Heating with radiators.
2. Heating with unit heaters.
3. Central groups of heating and ventilating systems.
4. Central groups of evaporative cooling systems.
5. Central groups of complete air conditioning systems using mechanical refrigeration or cold well water or a combination thereof.

The major trend of practise is definitely to use either heating with unit heaters, opening the windows in summer, or to go to complete year 'round air conditioning. Heating with radiators has been considered impractical for these large plants because of the steam distribution and control problem, and its use is therefore confined to the relatively small plant.

Numerically, plants providing simple heating are employing unit heaters almost exclusively, since this method eliminates all ductwork other than air intakes, and usually results in lowest first cost consistent with excellent results. The projection type using propeller fans appears to be favored for buildings of low and moderate ceiling height, whereas with high ceilings or for applications requiring long blows, the centrifugal fan heat diffuser is favored as would be expected. Direct gas fired heaters have been used in several instances.

There are a few notable exceptions to the use of unit heaters, and these have been in assembly factories where process steam has not been required. Under such circumstances, direct-firing of oil in central air heating equipment has been of advantage. This method implies one or more centralized duct systems, and a preferred arrangement has utilized under-floor ducts, either metal or concrete, distributing air by risers at columns, or through grilles located in the floor. Central ventilation is also used to take care of excessive concentrated heat loads which are commonly partitioned off from the main space. One practise in this respect is use of the displacement method introducing air near the floor and exhaust at the ceiling with a relatively high air change and with provision for spot cooling of the employees. Such design to be successful must be quite flexible, and should take into account the type of occupancy.

An important heating requirement relates to the large doors in assembly plants which must be opened wide in midwinter. Heat diffusers may be used to blow a continuous curtain across from the sides and downward from overhead locations. The central underground duct permits a continuous slot in the floor the length of the door opening. These methods are all satisfactory on calm days, but can hardly be expected to function adequately with high wind.

A modification in recent heating technique is the use of the blackout ventilator and blackout heater, both offsprings of the war. These devices are equally applicable to new and existing buildings, and recognize the obvious fact that mechanical ventilation must be provided when a building with movable sash is blacked out. The ventilators are simply supply or exhaust fans, incorporating a seal or baffle to prevent passage of light, an intake or hood to prevent entrance of rain, means of attachment to the roof or wall, and adequate facility for picking up or distributing the air. The blackout heater is a supply ventilator with heating coil. If factory operation under blacked-out conditions becomes necessary, such equipment will achieve considerable importance.

Evaporative cooling has not been used to any large extent, except in a few plants for the cooling of spaces subjected to excessive internal heat loads. Apparently the potentialities of this method for producing improved comfort have been overlooked for many plants, particularly those with heavy heat concentrations. Evaporative cooling can by no means be construed as giving comfortable conditions all summer long. But it is capable of giving results equal to complete air conditioning during the fall, winter and spring seasons, and results definitely superior to straight ventilation, with lower air changes, in the summer time (Table 1). The chief reason for considering evaporative cooling now lies in the non-use of many of the critical materials required for complete summer air conditioning.

Air Conditioning Technique

Of considerable interest to the engineer is the question of design

heating and cooling loads for these large plants. Heating loads are comparatively small in a windowless factory, since roof and usually walls are insulated, and heating is largely a question of tempering ventilation air in the coldest weather. Some of these plants have an internal load requiring cooling (by outside air) down to external temperatures of 10 or 20 F. This is not at all true of factories with sash in sawtooth or monitor, where the heating load becomes a major consideration, and is largely a function of the amount of glass used.

With respect to summer cooling, the external load on the windowless plant is comparatively small, due again to roof insulation. The internal load is highly variable, but is mainly a function of the horsepower of machines in operation. Electric lights and people are additional sources of room load. Table 2 presents tabulated values of load which may be considered to cover the average range of windowless building application. *Section A* shows a moderately low concentration of people and electric lighting; in *Section B* these items are moderately heavy.

No truly centralized system of ventilation or air conditioning is feasible because of the vast dimensions of the spaces to be conditioned. A single central system would involve ducts of impractical length and section dimensions, and apparatus of excessive size. At the present time, 400 ft has been considered about the maximum for the length of an air duct, and even here uniform distribution is somewhat of a problem. The practical considerations limiting duct size are the problem of running the duct between steel members of trusses; the progressively greater difficulty in stiffening and bracing ducts as the size increases; the greater load imposed on trusses and building columns by trunk ducts; the obstruction to lighting; and the greater difficulty of balancing air distribution as size increases. The limits on size of fans, coils and washers are those imposed by available headroom, load concentration and the departure from standard equipment available on the market.

All of these limitations are economic rather than technical, and while systems of almost any size can be built, the economic maximum seems to be at about 100,000 cfm in one system, with preferred practise falling between 40,000 and 65,000 cfm. This latter range appears to result in the lowest overall cost when related to the building structure. Although small units are feasible, the problem is quite different from unit heaters and heat diffusers where there are no ducts, piping connections are simple, and maintenance is at a minimum. The experience of the industry has pretty well proved, over a good many years, that a multiplicity of small conditioning equipments is economically justified only where space for large apparatus and ducts is at a premium or not available at all, or where a fine degree of zoning is essential. Neither situation is a factor in the blackout plant.

The preferred arrangement of air conditioning equipment is off the floor, with location at appropriate intervals either on a mezzanine extending along one or both of the long sides of the building, or up in the trusses, or on mezzanine platforms distributed at proper locations throughout the work area. While the latter arrangement does cut down somewhat on the size of ducts, it may be an objectionable obstruction to ceiling height in many plants.

Most of the plants already constructed employ finned cooling coils, and a few of them have used a single coil served by a central water circulating system for both heating and cooling, at considerable economy in the cost of surface. Direct expansion is used in some cases where the condensing equipment is located nearby. With the national effort to conserve copper, it is probable that spray dehumidifiers may

Table 2—Heat Loads and Air Quantities for Windowless Buildings

A—People Concentration: 160 Sq Ft per Person. Lights: 1.5 Watts per Sq Ft

Hp/1000 sq ft	0.5	1.0	1.5	2.0	3.0	5.0	7.5	10.0	15.0
Rm. Sens. Heat Btu/hr/sq ft	13.0	14.5	16.0	17.5	20.5	26.5	34.0	41.5	56.5
Grand Total Heat Btu/hr/sq ft	17.5	19.0	20.5	22.0	25.0	31.0	38.5	46.0	51.0
Δt = Temp. Diff. Between Room and Supply Air (F)	Cfm/1,000 Sq Ft (Upper Figure), and Air Change, Minutes (Lower Figure)								
5 F	2400 8.3	2700 7.4	3000 6.7	3250 6.2	3800 5.3	4900 4.1	6300 3.2	7700 2.6	10,400 1.9
10 F	1200 16.7	1350 14.8	1500 13.3	1620 12.4	1900 10.5	2450 8.2	3150 6.4	3850 5.2	5,200 3.8
15 F	800 25	900 22	1000 20	1080 18.5	1270 15.7	1630 12.3	2100 9.5	2600 7.7	3,500 5.7
20 F	600 33	680 29	750 27	810 25	950 21	1220 16.5	1570 12.7	1920 10.4	2,600 7.7
25 F	480 42	540 37	600 33	650 31	760 26	980 20	1260 16	1540 13	2,080 9.7

B—People Concentration: 80 Sq Ft per Person. Lights: 3 Watts per Sq Ft

Hp/1000 sq ft	0.5	1.0	1.5	2.0	3.0	5.0	7.5	10.0	15.0
Rm. Sens. Heat Btu/hr/sq ft	19.5	21.0	22.5	24.0	27.0	33.0	40.5	48.0	63.0
Grand Total Heat Btu/hr/sq ft	28.5	30.0	31.5	33.0	36.0	42.0	49.5	57.0	72.0
Δt = Temp. Diff. Between Room and Supply Air (F)	Cfm/1,000 Sq Ft (Upper Figure), and Air Change, Minutes (Lower Figure)								
5 F	3600 5.5	3900 5.1	4200 4.8	4500 4.5	5000 4.0	6100 3.3	7500 2.7	8900 2.3	11,600 1.7
10 F	1800 11.1	1950 10.2	2100 9.5	2250 8.9	2500 8.0	3050 6.6	3750 5.3	4450 4.5	5,800 3.5
15 F	1200 16.7	1300 15.4	1400 14.3	1500 13.3	1650 12.1	2050 9.8	2500 8.0	2950 6.8	3,900 5.1
20 F	900 22.0	970 21.0	1040 19.3	1110 18.0	1250 16.0	1520 13.2	1870 10.7	2220 9.0	2,900 6.9
25 F	720 28.0	780 26.0	830 24.0	900 22.0	1000 20.0	1220 16.4	1500 13.3	1780 11.2	2,330 8.6

Notes: (1) Outside conditions: 95 F DB, 78 F WB; inside: 80 F and 50 per cent.
(2) Roof assumed insulated.
(3) One horsepower taken as 3,000 Btu per hour, to allow for motor losses dissipated to room
(4) Air change based on 20 ft ceiling height. For other heights, correct in proportion.
(5) Grand total heat includes ventilation load of 10 cfm per person.

be considered in some of the future plants to avoid the use of copper coils.

Ducts are usually straight single runs, with air velocities up to 2,000 fpm or higher. Ceiling type diffuser outlets of large capacity are in general use, but a real problem of air distribution is involved in winter with ceiling heights greater than 30 ft. The conventional diffusion outlet ejects little or no air with the downward velocity necessary to produce adequate mixing during the heating season. Progress is being made by several designers, however, in developing diffusers with manual or automatic direction and velocity control for this specific purpose. This distribution problem is more difficult for the building with windows, where heat losses from glass result in a relatively high temperature differential between supply air and room. With a windowless plant this becomes a problem only on the very coldest days, since the internal load is normally sufficient for most of the heating.

Air cleanliness is of paramount importance to aircraft engine plants and any other factories performing high precision machine work. Electric precipitating equipment is a favored method for this service.

Refrigeration Equipment

These vast projects require huge tonnages of mechanical refrigeration. There has been much discussion in the technical press concerning the wisdom of centralizing this equipment in one location as opposed to decentralizing it in comparatively small units scattered throughout the plant. The major claims by the proponents of decentralized refrigeration are the minimized effects of bombing or sabotage, the saving of floor space, the ability to stock identical spare parts, improved flexibility of zoning and saving in duct work.

Since the air conditioning equipment must be decentralized anyway, as explained previously, the claims for flexibility of zoning and saving in ducts are hardly valid. The stocking of standardized spare parts would hardly be expected to offset the excessive maintenance of a large number of such equipments. The saving of floor space by location up among the trusses or on the roof is probably more than offset by the advantages of having the mechanical refrigerating equipment centralized in one or two spots. However, there remains the foremost and major contention of the proponents of decentralization—that is, avoidance of the effects of bombing and sabotage. This claim requires a careful consideration of all the factors involved.

No mechanical equipment can withstand a direct bomb hit without being extensively damaged. If the refrigeration equipment is distributed among a large number of small systems all over the plant, a bomb hit anywhere is probably going to wreck the unit in the immediate vicinity of the hit. Since these systems are direct expansion, the blast effect of the explosion will unquestionably open up the refrigerant piping in all of the systems in the vicinity of the hit, the radius depending upon the size of the bomb. Inasmuch as fire will almost inevitably result, consideration must be given to the effect upon workmen and fire fighters of the decomposition products of the refrigerant when exposed in considerable quantities to open flames. Outside of this factor of impeding fire fighting and possibly contributing to a panic, it is certainly evident that such a hit will not merely demolish a single unit but in all probability will put a good many more units out of service.

The centralized refrigeration plant is not subject to these objections. It too will be put out of service with a direct hit, but the statistical odds against a direct hit are very large. The refrigeration plant can be put underground and located in its own equipment room, and therefore can be made relatively immune to the blast effect of any nearby explosions. Any decomposition products caused by fire in the refrigeration room will be confined therein and not spread into the working spaces. The use of chilled water instead of direct expanding refrigerant eliminates the hazard in the working spaces, and furthermore the water piping may run largely underground and if hit or damaged can be fairly promptly repaired.

In addition to these important safety features of the central refrigerating plant, it is obvious that from the viewpoint of operation and maintenance the problem is vastly simplified over that required with a multitude of small equipments. With the air handling equipment necessarily decentralized, the flexibility in shifting load from zone to zone as required is even greater than where the refrigerating capacity is a fixed quantity for each zone.

Speaking broadly, decentralization of refrigeration should bear some relation to the decentralization of buildings and of the mechanical equipment therein. This must follow the master plan of the government concerning the construction of plants within the effective bombing range, which is generally considered within 300 miles of the east or west coastlines. Some of the plants mentioned are thus located and here decentralization of plant is being effected by separation of buildings by at least several hundred feet and in some cases by several thousand feet. In plants where the bombing factor is considered one for such vital precautions, a valuable guide for the refrigeration can be obtained from the practise with regard to the boiler plants. Obviously heating is more important than cooling in order to insure continuous production and if it becomes necessary to decentralize boiler equipment it can be logically assumed that equivalent decentralization of the refrigeration is in order.

The outstanding example of decentralization is at Douglas where there are 11 separate buildings of which four are the general manufacturing plants. The total project includes 23 boiler rooms and 68 self-contained direct expansion air conditioning and refrigerating systems averaging 60 tons, for a combined total of 4,026 tons of refrigeration. Such extensive complication has not been found necessary in most other large projects that are fully air conditioned. Packard with 1,000 tons, Allison 2,550 tons, Ford 6,000 tons, Wright 6,000 tons, Consolidated with 7,000 tons, and others, have all used centralized refrigeration plants and have discarded as impractical any idea of complete decentralization of boilers and refrigeration.

Probably the soundest answer, if it is not desired to put all eggs in a single basket, is to divide both

boiler and refrigeration equipment into two or possibly three plants at opposite ends of the project. At slightly greater expense the steam and chilled water distributing systems can be interconnected to provided with adequate river or well ditioning for the entire factory in case one of the plants is put out of service.

While cooling towers are conventionally used in most of the air conditioned blackout plants not provided with adequate river or well water, it is of interest to note that a few factories have adopted roof spraying or roof ponds for the dual purpose of cooling the condenser water while simultaneously reducing the solar transmission through the roof to a negligible value.

Summary

In conclusion it can be stated that certain trends affecting our industry are evident as a result of the enormous expansion of industrial plants during this war emergency. It is true that there is nothing new or revolutionary in the engineering and design technique employed in heating or air conditioning a blackout plant. Outside of the problems arising out of building size, methods follow the sound practises built up over a good many years. Of considerably greater importance than the application technique is the extent to which air conditioning has been applied.

Not only is air conditioning being used in sizes hitherto unthought of. More significantly, air conditioning is being employed in more different kinds of plants, and for more different processes than ever before. No longer is it confined to industries where production without it is impossible. It is being employed in plants where production without conditioning has been feasible in the past. There is only one reason for its use, but that reason is so basic, so vital and so compelling that all other considerations are thrown completely to the wind. That reason is the paramount necessity for speed, speed and more speed; the importance in reducing rejects and spoilage to an absolute minimum, and the necessity for keeping every man and every machine at peak production efficiency until the threat to our national existence has been overcome.

This trend cannot help exerting a profound effect upon our industry in the years to come. That is important in the long-term view. It is wholly secondary at the moment. For while true it may be that our armament program has advanced air conditioning—the vital factor right now is that air conditioning is recognized as an essential industry advancing our armament program.

DISCUSSION

W. L. FLEISHER: It was pleasant to note that the author referred to my activities in connection with evaporative cooling for industrial plants, but I also want to correct a misunderstanding which has been prevalent for a number of years—that I have been advocating evaporative cooling for maximum comfort in all types of buildings and under all circumstances.

In December 1936, I presented a paper before the *American Society of Refrigerating Engineers,* entitled "Evaporative Cooling for Comfort." This paper having been presented before a refrigerating society, created a great amount of comment and criticism, the assumption being that if I presented such a paper before a refrigerating group, I was advocating the dis-use of refrigeration for comfort in lieu of evaporative cooling. In that paper and in many papers and talks since, I have stated and have shown by figures and by other references that under many conditions of outside wet-bulb, comfort conditions could be obtained by proper evaporative means, independent of refrigeration, but that when the outside wet-bulb reached 70 deg comfort could not very well be obtained. I pointed out that the work that was carried on in the ASHVE Research Laboratory under the Technical Advisory Committee on Air Conditioning in Industry, showed that safety for the worker, from a physiological standpoint, could be maintained with a properly designed evaporative cooling system, whereas with straight ventilating or air change, with outside conditions of 95 deg dry-bulb, a condition would arise inside the building of approximately 105 deg and 88 or 89 deg ET, possibly more, which conditions would definitely be unworkable or unproductive and would result in inefficient production, not justified by the fact that with evaporative cooling no more fundamental or basic material would be required than with straight ventilating and that conditions below 83 deg ET temperature could be maintained. If the cooler air were obtained by evaporation and directed with a certain velocity at the workers, they would have a feeling of comfort which would be definitely beneficial to their production of material.

I have presented these facts to the War Production Board in Washington and asked that they define accurately what they meant by air conditioning; that certainly for blackout buildings in industry, ventilation was required and that evaporative cooling was not air conditioning, but simply a refined method of ventilation, which, by the very results obtained, could not be construed as air conditioning, as covered by the definition of the ASHVE. I have been informed that the War Production Board's Air Conditioning and Refrigeration Division was giving very careful consideration to my request and that the likelihood of having evaporative cooling under these circumstances defined as ventilation and not refrigeration might be expected.

I wish to compliment the author on the very careful analysis he had made and again assure him of my appreciation of his reference to the great amount of work that I had done to make this type of ventilation or conditioning available to the manufacturer and the general public.

D. L. FISKE NOW A MAJOR

David L. Fiske, executive secretary of the *ASRE,* who was called into service as a reserve officer in October 1941, has recently been promoted to the rank of Major in the U. S. Army. He is now serving in the Control Branch, Services of Supply, in Washington, D. C. Alfred Chadburn, Jr., formerly of Cincinnati, was elected assistant secretary of the ASRE at the board of directors meeting of the Society in Skytop, Pa., June 7, and took over Major Fiske's duties at the headquarters office in New York on July 1.

Proceedings of the Semi-Annual Meeting 1942

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

St. Paul Hotel—June 15-17, 1942—St. Paul, Minn.

THE SOCIETY'S SEMI-ANNUAL Meeting 1942 was the main attraction for 200 members and guests, who came to St. Paul, June 15-17, for a discussion of papers, which were not only of current interest, but provided fundamental information that is useful to engineers engaged in war work, involving heating, ventilating and air conditioning.

FIRST SESSION—Monday, June 15, 2:00 p.m.

At 2:00 p. m. on Monday, the first technical session was called to order by Pres. E. O. Eastwood, and William McNamara, president of the Minnesota Chapter, gave a word of greeting, and then introduced Frank Madden, secretary to Mayor McDonough, who made a speech of welcome on behalf of the City of St. Paul. He outlined, in a most entertaining way, some of the many attractions that awaited the members.

A brief response was made by President Eastwood, who expressed the appreciation of the Society for the cordial greeting from the City officials and the people of St. Paul.

President Eastwood then called for the presentation of the paper, Performance of a Forced Warm-Air Heating System as Affected by Changes in Volume and Temperature of Air Recirculated, by A. P. Kratz and S. Konzo, (complete paper published in June 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*) which was presented by Professor Kratz. He explained that this two-year investigation revealed seven significant factors in the performance of a forced warm-air heating system under stoker operation. The data developed will be helpful to the designing engineer in selecting and checking design conditions for a plant, estimating the effect on comfort of varying rates of air change, intermittent operation, air deliveries, duct system and room temperature gradients.

Comments were offered by E. K. Campbell, Kansas City, Mo., John Everetts, Pittsburgh, and W. L. Fleisher, New York.

E. K. CAMPBELL: This is a very timely paper. It cannot be stressed too often or too much that air volume should be proportioned to the Btu load required to produce comfort conditions within the building or room.

While this paper is prepared entirely from the standpoint of residence heating, the things that are pointed out have their application in all types and kinds of buildings.

Paul Bunyan Comes to St. Paul
Mayor McDonough of St. Paul (*seated*), E. F. Jones, M. H. Bjerken, D. B. Anderson, R. E. Backstrom, G. F. Hoppe, Paul Bunyan (*left to right*)

For instance, the introduction of the air at the floor producing three degrees lower temperature differential is comparable to the modern practice with unit heaters, discharging the air downward so that it strikes the floor and mixes with the cold air on the floor, thereby producing a large induced circulation and raising the temperature at the floor and reducing the temperature at the ceiling.

In audience room work it is not desirable to stop the fan at any time the audience is in the room, while in the residence work intermittent operation of the fan, according to the temperature of the room, is desirable. The fact that the air movement determines the temperature differential means that in a high ceiling room if the fan is stopped, immediately the air which is cooled by the walls and windows drops to the floor and tends to lower the temperature in the lower strata of air which are the ones which determine the comfort of the audience. Also if the room is a little warm it is necessary to maintain motion next to the body in order to carry away the body heat as rapidly as possible. So the fan must operate constantly while the audience is in the room and the air must be introduced in such a way that if it does come in cool it does not cause an objectionable draft anywhere within the room. With these things in mind it is then necessary not only to determine the volume of air according to the Btu load, but it must not be introduced at too high a temperature. In our practice we have found it advisable to restrict the temperature rise of the air to approximately 40 to 45 degrees, with 55 deg temperature rise as the air passes over the heating surface as the maximum for good practice. That means that each cubic foot of air absorbs from two-thirds to one Btu as it passes over the heating surface.

Temperature rise of less than 40 deg can be used successfully in very large rooms where the air can be introduced high enough to permit thorough mixture with the other air so as to prevent objectionable drafts.

Any paper that spreads the gospel of large volumes at lower temperatures and reasonable size ducts instead of the extremely small ones that we sometimes see, helps to advance the art of heating by air movement.

JOHN EVERETTS, JR.: I notice that the authors state that register temperatures as low as 94 F and 103 F might be used with the larger quantities of air. It has been my experience that such low register temperatures always created an uncomfortable condition and that this discomfort was only alleviated after the register temperatures had been raised

to at least 110 F. As the authors do not show in the paper any actual test with such low register temperatures, I would like to ask if they actually tried these temperatures and what comfort conditions they experienced.

W. L. FLEISHER asked Professor Kratz whether he took measurements of the relative humidity prevailing at the same time that he took dry-bulb readings of the conditions prevailing in the house.

Professor Kratz replied that these readings had not been taken, but that they thought the relative humidity was about 28 to 30 per cent. Mr. Fleisher was critical of the fact that a paper presented to the Society as indicating the performance of a heating system should not have included the relative humidity as an important function of the maintenance of comfort. Studies are being made to determine just what effect the moisture content has on the requirements for heating, and what the psychological reaction on the occupants is with higher or lower relative humidities. The 28 to 30 per cent relative humidity which Professor Kratz thought prevailed during these tests was a relative humidity which in Mr. Fleisher's opinion was a reasonable moisture content to prevent uncomfortable dryness. He thought that the authors should include reference to relative humidity, give some conclusions drawn from the relative humidity prevailing, or make a test to find what would have been required in the way of fuel consumption with different amounts of moisture in the enclosure before the paper appears in the Society's TRANSACTIONS.

AUTHOR'S CLOSURE: Mr. Everetts questions the feasibility of operating with register air temperatures below 110 F. Later tests than those reported in the paper have proved that with high sidewall registers it is possible to obtain satisfactory comfort conditions with register air temperatures as low as 95 F. With baseboard registers, however, the authors are inclined to agree with Mr. Everetts that temperatures below 110 F may be questionable.

President Eastwood then called on C. F. Warner, co-author with M. C. Stuart and W. C. Roberts, to present the paper, Effect of Vanes in Reducing Pressure Loss in Elbows in 7-inch Square Ventilating Duct (complete paper to be published in September ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*). Mr. Warner indicated that the paper covers an investigation of a 7x7 in. square elbow with round and square inside and outside corners and various radius ratios. He further explained that data reported show reduction of pressure loss in elbows by the use of vanes and splitters, and then stated that visual flow patterns in elbows are shown utilizing a *schlieren* apparatus.

Mr. Fleisher expressed the thanks and appreciation of the membership for the valuable contribution which resulted from these cooperative research studies.

As the concluding presentation, F. W. Hutchinson, co-author with B. F. Raber, presented the paper, Trend Curves for Estimating Performance of Panel Heating Systems (complete paper published in July 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*).

Before adjournment R. E. Backstrom, General Chairman of the Committee on Arrangements for the meeting, announced the program of entertainment events and invited all members to participate.

SECOND SESSION—Tuesday, June 16, 9:30 a.m.

The second technical session was called to order by President Eastwood at 9:30 a. m., Tuesday, June 16, and he introduced First Vice-President M. F. Blankin who conducted the meeting.

The first paper, Overloading of Viscous Air Filters During Accelerated Tests, by Frank B. Rowley and Richard C. Jordan, was given by Professor Jordan (complete paper published in July 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*). Professor Jordan explained that dry filters have no tendency to overload during accelerated tests, but with oil filters overloading may occur if the rate of dust feed is more rapid than the rate with which the adhesive can absorb the dust. Tests conducted on viscous filters with comparatively light adhesives, he stated, showed no appreciable change in efficiency with temperatures between zero and 130 F. He went on to say that by tests conducted on various carbon and lampblacks, it was found that a dust to possess non-overloading characteristics when used as a component of a filter test dust should have a high rate of oil absorption. One dust mixture tested was found capable of duplication and possessed non-overloading characteristics.

W. A. Grant, Philadelphia, gave his paper entitled, Air Conditioning of Blackout Plants (complete paper is published in this issue, see p. 509). He brought out that the huge expansion of industrial plants, due to the war, has introduced air conditioning in more kinds of plants and in more different processes than ever before. Outside of the problems arising from the enormous size of the buildings, he stated, the engineering design methods follow well established application practices. With speed the paramount factor in the armament program, air conditioning has been classed as an essential industry for reducing product rejects; maintaining spoilage to a minimum; and keeping every man and machine at the peak of production efficiency.

In commenting on this paper Mr. Fleisher made a suggestion that a special committee should be formed to study the air conditioning question of blackout plants.

Second Vice-President S. H. Downs introduced Lt. Commander A. R. Behnke (MC) U.S.N., who presented an interesting address on physiologic studies pertaining to Naval ventilation. At the conclusion of a very interesting discussion of this subject, Mr. Downs introduced Dr. Charles Sheard, director of the Division of Biophysical Research of Mayo Foundation. Dr. Sheard's subject was on some further investigations of calorimetric and skin temperature measurements of the extremities and their significance.

THIRD SESSION—Wednesday, June 17, 9:30 a.m.

The third and final technical session was opened by President Eastwood, who introduced D. B. Anderson, whose subject was, Heat Loss Studies in Four Identical Buildings to Determine the Effect of Insulation (complete paper published in this issue, see p. 499). With the aid of slides and a movie film, Mr. Anderson indicated that actual fuel savings effected by installing various thicknesses of insulation in four identical dwellings of typical construction were determined and compared with calculated results. Inside wall and glass surface temperatures were observed, together with the actual air temperature gradients from the floor to ceiling. In addition, data are included giving basement and attic air temperatures for the insulated and uninsulated structures.

N. D. ADAMS, Rochester, Minn.: The results reported in this paper are of great value. It would seem that the Society is in

a position to inform the public from time to time concerning the proper materials and equipment which would permit the builder to make a wise economic choice. The current conditions are most confusing to the purchaser, who is confronted with a great number of viewpoints dealing with the selection of competitive materials, such as insulation.

The data reported in this paper together with other available Society data should be incorporated in a bulletin for the use of the consumer. Such a pamphlet issued by the Society might be entitled, The Economy of Good Building Construction, which could include such information as the following: (1) material—how much to use, cost and saving in fuel; (2) insulation—recommended thicknesses in walls, ceilings and wall exposure; (3) storm windows—weatherstripping; (4) heating system—reduction in size and cost due to the proper selection of materials and the annual fuel savings which can be obtained on a degree-day basis.

E. K. CAMPBELL: I desire to compliment the authors of this paper on the very painstaking, tremendous amount of work involved in the preparation of this paper and results they are able to show.

Several years ago Mr. Close presented a paper dealing with the economical thickness limit of insulation, and pointing out that the limit was about an inch and a half thick. Beyond that the insulation did not pay its way. Up to that it very markedly did pay its way. That conclusion by Mr. Close is very closely borne out by this paper, which shows that two thicknesses very definitely paid their way but when the third thickness was added the increased saving was thought insufficient to justify the cost.

Another thing just pointed out by Mr. Adams in a conversation is that now when people come to us and want to know something about the saving in fuel resulting from proper insulation of the house, we are able to tell them pretty definitely; it is a valuable piece of work.

President Eastwood introduced the author, C. O. Wood, co-author with Gordon B. Wilkes of the paper, The Specific Heat of Thermal Insulating Materials, which he presented (complete paper published in June 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*). He explained that in order to provide data which have thus far been lacking, the authors have experimentally determined the specific heat of fifteen of the more common insulating materials. The mean specific heats, he brought out, were determined for the temperature range within which the materials are generally used. This range was from 80 to 212 F for the organic insulators and from 80 to 1350 F for the higher temperature materials. True specific heats were calculated for the materials used above 212 F. He included in the paper a discussion of the importance of heat capacity as applied to thermal insulation.

JOHN JAMES, New York, N. Y.: Prior to the reporting of these tests, only meager data have been available in the various engineering handbooks on the specific heats of common insulating materials. Hence, the results reported in this paper will serve a useful purpose in the literature of the Society. At the present time some analytical work is being conducted at the ASHVE Research Laboratory on the heat flow through various combinations of wall construction, and as one phase of the calculations involves heat capacity, it will be readily observed that the data in this paper will be of value. The Society is now sponsoring a cooperative research project at Columbia University to determine the heat gain through walls utilizing an electrical analyzer. The accuracy of the results obtained from this electric device depends largely on the reliability of constants fed into the machine. One of these constants is the specific heat of a material and for that reason the results given in this paper will be of great interest to those working on this project.

E. C. LLOYD, Lancaster, Pa.: The authors are to be congratulated on an excellent paper which supplies some much needed data on the specific heat of insulating materials commonly used in both high temperature and low temperature work. Heretofore, values for the specific heat of many of these materials have been lacking, and the paper therefore serves a long felt need by providing reliable information on the 15 materials tested.

An inspection of the results given in Table 1, places the materials in three definite classes—inorganic materials showing a specific heat of 0.2 to 0.25, organic materials other than corkboard showing a specific heat of 0.33 to 0.35, and corkboard showing a value of 0.4. Since corkboard, as well as two of the organic materials tested, is largely cellulose, it is difficult for me to see why this difference should come and I should like to inquire of the authors if any tests were made of wood as I feel that possibly the woody materials would occupy a place between the fibrous materials and that occupied by cork, or might possibly show a specific heat even in excess of the value given for corkboard.

G. B. WILKES: In answering Mr. Lloyd's comments, I regret to state that no determinations of the specific heat of wood were made during this investigation. According to *Marks' Handbook*, the specific heats of pine, oak and fir are between 0.45 and 0.67, although the source of these data is not given. The specific heat of cellulose is given as 0.32 by the International Critical Tables. The wood fiber blanket and the wood fiber board have specific heats very close to this cellulose value. I presume that corkboard has a higher specific heat than pure cellulose on account of the resins, etc., that remain in the material and which probably have a much higher specific heat than cellulose. The value for corkboard is not as high, however, as the values for three types of wood as given by Marks.

The final paper at the session, Simultaneous Heat and Vapor Transfer Characteristics of an Insulating Material, by F. G. Hechler, E. R. McLaughlin and E. R. Queer (complete paper to be published in September ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*) was presented by John James, technical secretary of the Society. Mr. James outlined the two major forces which influence the transfer of vapor through building insulations, and described the two types of moisture movement and the results of investigations and the operation of the test equipment used for determining moisture and vapor conditions. He pointed out that it was demonstrated that moisture can collect in or be driven from specimens under test and that the conductivity is not appreciably affected by the first 7 per cent moisture.

At the conclusion of the discussion, W. H. Driscoll, past president of the Society, paid tribute to the past presidents who had died within a few months. He said that it is a strange and sad fact that the Society has lost three of its very prominent past presidents and its last honorary member within a short time. Not in the history of the Society had such a tragedy occurred, and he felt that it was appropriate to recall some of the contributions that had been made by these gentlemen, so that the younger members might fully appreciate the extent of their activities, not only in their own, but in other fields of endeavor.

REGINALD P. BOLTON (October 5, 1856-February 18, 1942) *Honorary Member and Life Member* was, perhaps, one of the most versatile men who ever served the Society. He was a most remarkable man and his interests extended into many fields and his engineering activities took him to many foreign

countries. He was a great historian and recorded the history of Manhattan Island, and was recognized as an expert on Indian lore. Mr. Bolton was a dynamic and fascinating individual whose long and active career was an inspiration to all who knew him.

JOHN HALE (November 11, 1870-May 29, 1942), *Life Member* was actively interested in the Society's work throughout his life. He was of an aggressive, bright and friendly personality. He was regular in his attendance at Society meetings and had the unusual distinction of serving as the Society's chief executive for two years, one year as acting president while the late John R. Allen was in Turkey, followed by his regular term as president of the Society. He was a fine committee member and served the Society well. The members will miss John Hale.

J. IRVINE LYLE (February 14, 1874-June 7, 1942) *Life Member* was buried just one week ago. He was one of the great characters in the Society and one of the small group who had the vision and the energy to conceive and bring into operation one of the Society's greatest endeavors, the Research Laboratory. He contributed many technical papers to Society meetings, and maintained an active interest in its Chapter work. He had wide interests in many other fields but always maintained a close contact with the work of the Society. He was a big man, striking in appearance, dignified, human and understanding. He was a great credit to the engineering profession and a staunch friend.

It is a great privilege to pay this tribute to all of these men who served the Society so well.

President Eastwood called on the Chairman of the Resolutions Committee, T. D. Stafford, who presented the following report:

Report of Committee on Resolutions

WHEREAS, the Semi-Annual Meeting 1942 of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has been an outstanding success in the City of St. Paul, Minnesota, June 15-17, 1942.

THEREFORE, BE IT RESOLVED, THAT an expression of thanks and appreciation be adopted by this meeting and be spread upon the minutes of the Society and copies thereof be transmitted to each of the persons and agencies who have contributed to make this meeting so enjoyable for the members of the Society who attended:

To the Minnesota Chapter members for the capable manner in which they fulfilled their position as hosts;

To Chairman R. E. Backstrom and the Committee on Arrangements whose careful and detailed planning have been revealed in every department of the meeting;

To Mrs. Backstrom and her Committee for their splendid entertainment of our ladies and to the citizens who kindly cooperated in welcoming them to inspect their gardens and those who furnished their cars for the trips;

To the Authors and Speakers at Technical Sessions for their instructive papers and able presentations;

To Dr. Walter H. Judd for his thorough analysis of our national crisis;

To newspapers and trade publications, whose columns have given advance notices and daily coverage of this Semi-Annual Meeting;

To the M. & O. Paper Co. for the able assistance of Leonard Costley (Paul Bunyan);

To Hal Olson and his talented assistants, Messrs. Algren and Jones, for their impersonations and feats of magic;

To E. H. Pitney of the War Production Board for his interesting address;

To Victor Johnson, Secretary of the Minnesota Tourist Bureau for the entertaining movies;

To the Wood Conversion Co. for the inspection and entertainment at the First National Bank Tower;

To the Faculty of the Engineering Department of the University of Minnesota, for their aid in arranging and conducting the tour of inspection;

To the management and all employees of the Hotel St. Paul for their unusually courteous and cooperative efforts;

To the St. Paul Association of Commerce for the assistance rendered by their Convention Bureau representatives;

To Mayor John J. McDonough and his Executive Secretary, Frank Madden, and to the various Municipal Departments and citizens of St. Paul for their splendid aid and cooperation.

AND WHEREAS the Society's world-wide influence; its advancement of technologic knowledge in the science of heating, ventilating, and air conditioning, to its present high level; the organization of its members into one friendly, firmly cemented, altruistic, cooperative union, culminating in successful meetings of lasting progress and innumerable endearing memories, has been accomplished only through the interest, unstinting labors, planning, and unselfish devotion to principle and mutual assistance of the Founders and former Officers of the Society;

THEREFORE, BE IT FURTHER RESOLVED, THAT an expression of congratulation and felicitation be adopted by this assembly and spread upon the minutes of the Society, and that copies thereof be transmitted to each of the Charter Members and Past Presidents of the Society:

To congratulate all Charter Members and Past Presidents on the salutary results of their efforts;

To express our pleasure at the attendance of so many Life Members and Past Presidents; and

To express to Charter Members and Past Presidents who could not be in attendance our sincere regret of their inability to be with us on this occasion.

Respectfully submitted,

THOMAS D. STAFFORD, *Chairman*
C. S. KOEHLER
J. DONALD KROEKER

Mr. Backstrom responded to the vote of thanks and appreciation which had been unanimously adopted, and then told of the pleasure of the members of the Minnesota Chapter in having the Society visit the Twin Cities.

President Eastwood announced that the registration had reached a total of 200, after which the meeting adjourned.

Council Meeting

A meeting of the Council, with 16 of the 18 members present, was held on Monday morning, June 15, at the Hotel St. Paul, and President Eastwood presided. Reports of Council committees indicated that the present membership status on June 1 was 3167. The Finance Committee presented some amendments to the budget on the basis of operations during the first five months of the year. The budget, exclusive of research, of $87,600.00 was approved.

A detailed discussion of research activities indicated that the program for the future would be devoted only to problems that might contribute to winning the war.

Nomination of five members to serve for three-year term on Committee on Research, beginning January 1943, was made as follows: H. J. Rose, Pittsburgh; L. P. Saunders, Lockport, N. Y.; L. E. Seeley, New Haven; A. E. Stacey, Jr., Washington, D. C.; and C. Tasker, Toronto. The resignations of nine members were accepted reluctantly and the membership of 132 members was cancelled for non-payment of dues.

Meeting of Chapter Representatives

On June 15, at the request of the Chapter Delegates present, Chairman J. F. Collins, Jr., called a meeting and the following were present: Albert Buenger, Cincinnati; C. E. Bentley, Golden Gate; E. M. Mittendorff, Illinois; A. L. Walters, Iowa; E. K. Campbell and W. A. Russell, Kansas City; M. B. Shea, Michigan; W. R. White, Nebraska; C. S. Koehler, New York; J. D. Kroeker, Oregon; H. B. Hedges, Philadelphia; T. F. Rockwell, Pittsburgh; T. D. Stafford, Western Michigan.

Mr. Kroeker reported that the threatened fuel shortage in the Pacific Northwest had caused the municipal authorities in the City of Portland to enlist the assistance of the Oregon Chapter to prepare a report and give publicity to fuel conservation measures.

The various chapter representatives outlined the methods being used in establishing dues rates for members in service.

Chairman Collins pointed out that all chapter officers should be advised that chapter rolls could include only members of the Society in good standing. The delegates present requested that the chairman communicate with all chapters in this matter.

It was announced that the Local Chapters Committee would be able to assist chapters that needed speakers this fall and letters should be mailed by the chairman to determine chapter requirements.

Entertainment

On June 14, early arrivals for the Semi-Annual Meeting of the Society were received by the Reception Committee in the Capitol Room of the St. Paul Hotel. At 6:30 on Sunday evening 75 members and guests gathered to enjoy the special smorgasbord dinner in the Club Casino, St. Paul Hotel. Following the dinner members enjoyed a motion picture showing Kodiak Bear hunting.

At noon on Monday, June 15, a get-together luncheon was held in the Club Casino with 145 in attendance, and E. H. Pitney of the Contract Distribution Branch of the War Production Board, gave an interesting discussion of the work.

During the day many of the visitors were mystified by the appearance of a *bearded giant* who carried a loggers ax, but the mystery was solved on Monday evening in the Club Casino when *Paul Bunyan* (Leonard Costley) told his story without exaggeration. The Minnesota members appeared in lumber jackets and boots for this occasion, and the Club Casino was set in logging camp style with long tables, tin plates and mountains of food. During the meal Mr. Costley told the story of *Paul Bunyan*, "who was a mythical hero of the lumber camps of the Northwest. The stories which have been told in American timberlands for generations are of Canadian origin, but American loggers below the border made of *Paul Bunyan* a true hero of camp nights' entertainment.

"They gave him Babe, the blue ox, who measured 42 ax handles and a plug of chewing tobacco between the horns. They created the mythical logging camp with the cookhouse of mountainous size, and they peopled this camp with astounding minor heroes.

"They made their *Paul Bunyan* an inventor and an orator and an industrialist whose labors surpassed those of Hercules. They devised a chronology for him; he ruled American life in the period between the *Winter* of the *Blue Snow* and the *Spring* that the *Rain Came Up from China*.

"In any case, the legend which is said to have begun in the Papineau Rebellion in Canada in 1837, when a *mighty-muscled, bellicose, bearded giant named Paul Bunyan raged among the Queen's troops like Samson among the Philistines*, had by 1860 spread throughout the Northwest, and perhaps even into the South where under the name of John Henry he became *the man worth talking about* in the work camp gang.

"Some evidence points to a French-Canadian origin among the loggers of Quebec or northern Ontario. Other evidences point just as strongly to an American beginning, possibly in Michigan or Wisconsin. In the Minnesota camps, the legends were undoubtedly enriched by Scandinavian myth, and there *Paul Bunyan* became a sort of modern Thor."

An unexpected feature of the program came when Paul carried in a miniature wedding cake with one candle and presented it with appropriate ceremony to Mr. and Mrs. George Hatch, Toronto, to celebrate the first week of their marriage.

The next entertainment feature was introduced by E. F. Jones, chairman of the Entertainment Committee, who presented Hal Olson, an impersonator and magician extraordinary. In some of his card tricks and illusions, he had the assistance of Prof. A. B. Algren, who literally lost his shirt on one occasion.

Following the entertainment a special sound movie showing the historic lakes and scenic features of the State was presented by Victor Johnson, secretary of the Minnesota Tourist Bureau.

A fitting climax for the entertainment program was provided by the dinner and dance at the St. Paul Hotel on Tuesday evening, June 16. Hors d'oeuvres were served in the Club Casino and a fine dinner followed in the Continental Room. Toastmaster H. E. Gerrish presented the officers, past presidents and distinguished guests at the head table. W. T. Jones, Boston, presented a memory book to Walter L. Fleisher, who was president of the Society in 1941. Mr. Fleisher expressed his thanks in the form of verse as follows:

Memory is a fickle thing
One day you think you are king
The next it's gone, perhaps it's Spring
And flowers crowd or rather cloud
Those happy days you said aloud
You'd ne'er forget.
And so it's good when work is done
And all deeds that you did are sung
To have a book in which is brought
The things and acts the papers caught,
So as you age and hair grows grey
To children and grandchildren say,
Those are the things I did!
Pandora, raise not the lid
You may not find, all thoughts are kind
So I forbid!
But no—on books do not rely
The written word may seal a lie!
I would not hold this book so dear
Unless in *you*, my memory's clear.

F. C. McIntosh, Chairman of Committee on Research, presented the Research Cup to Roy E. Gorgen, Minneapolis, who had a low net of 69. The Eichberg Memorial Cup was presented by M. F. Blankin to Capt. E. F. Bell of the Minnesota Chapter team, consisting of Messrs. R. E. Gorgen, E. L. Knowles and E. F. Bell. Mr. Bell, Chairman of the Golf Committee, announced the names of others who were rewarded for their efforts on the golf course: *Low Gross*—Arthur Nutting; *Low Net Gross*—A. O. May, 71; M. F. Blankin, 77; G. B. Priester, 78; Richard Ordway, 78; J. H. Milliken, 78; F. H. Gaylord, 79; J. C. Matchett, 80; M. W. Bishop, 80; F. H. Schern-

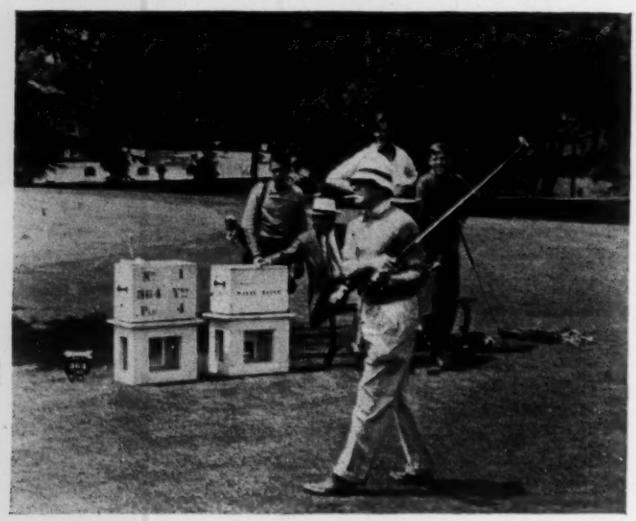
Scene at the Paul Bunyan dinner

All ready for the Research Cup tournament

(See opposite page)

Paul Bunyan tells Chairman Backstrom and M. S. Wunderlich his axe has served him well

Professor Kratz presents flowers to Paul Bunyan



W. L. Fleisher drives one in the Research Cup tournament

M. F. Blankin at the 1st tee

←(*Front row—left to right*) E. F. Jones, E. O. Eastwood, W. A. Russell, M. F. Blankin, F. H. Schernbeck, W. L. Fleisher. (*Second row*) Messrs. Schernbeck, Wm. McNamara (*seated*), Wm. Sturm, J. F. Stafford, M. H. Bjerken, E. F. Bell, A. Nutting, J. H. Milliken, E. M. Mittendorff, C. E. Price, Harry E. Gerrish. (*Back row*) N. D. Adams, F. H. Gaylord, R. E. Backstrom.

beck, 83; A. B. Algren, 85; B. L. Casey, 86; and C. E. Price, 86.

Blind Bogey: V. J. Jenkinson, 77; H. E. Gerrish, 76; and E. Anderson, 83. *High Gross*: Albert Buenger, 131. *Most 8's*: L. T. Avery, 4; and A. L. Byfield, 4. *Most 6's*: William Strum, 6. *Most 7's*: N. D. Adams, 6.

The principal speaker, Dr. Walter H. Judd was introduced and gave a stirring talk on the subject *Behind the Conflict in the Pacific*. He recalled some of the incidents of his life in China and gave a clear insight into the methods of thought followed by the Orientals. At the conclusion of Dr. Judd's speech, the room was cleared for dancing.

As soon as the ladies registered they were greeted by the Ladies Committee of the Minnesota Chapter under the direction of Mrs. R. E. Backstrom. Tea was provided on Monday afternoon to 42 ladies at the Women's City Club, St. Paul, and they enjoyed an interesting talk.

On Tuesday morning private cars were provided for sightseeing trips in the Twin Cities and 44 ladies enjoyed luncheon at the Coffman Memorial Union at the University of Minnesota, and then toured the Minnetonka Lake district and visited several formal gardens on private estates.

On Wednesday 40 ladies enjoyed a luncheon and card party. There were eight tables and the prize winners were: Mrs. E. M. Mittendorff, Chicago; Mesdames E. Uhl, C. T. Lawrence, E. L. Knowles, F. H. Schernbeck, A. B. Newton, A. W. Schultz, all of Minneapolis; and Miss Dorothy Matchett, Chicago; Mrs. R. C. Colman, St. Paul and Mrs. C. O. Carlson.

PITTSBURGH ELECTS OFFICERS

May 11, 1942. The monthly meeting of the Pittsburgh Chapter was called to order by Pres. E. C. Smyers at the Architectural Club, Pittsburgh, and a buffet supper was served prior to the meeting. The minutes of the April meeting were read and approved, and Prof. T. F. Rockwell then read the report of the nominating committee which reported the following officers elected to serve for the coming year:

President—C. M. Humphreys
Vice-President—G. G. Waters
Treasurer—L. S. Maehling
Secretary—E. H. Riesmeyer, Jr.
Board of Governors—E. C. Smyers, H. B. Steggall, T. F. Rockwell.

Following a movie with Africa as the setting, the members enjoyed several entertainment features, followed by adjournment.

April 13, 1942. The April meeting was held in the Marine Room of the Hotel Roosevelt with President Smyers presiding and 35 members and guests were present. The minutes of the previous meeting were approved as read, and several committee reports were presented, including the list of candidates to be elected for the ensuing year.

F. C. McIntosh made a motion, seconded by J. F. Collins, Jr., and passed, that the following resolution be adopted and a copy be sent to the family of the late Percy Nicholls:

BE IT RESOLVED THAT the Pittsburgh Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has suffered a great loss in the passing of Percy Nicholls, *Life Member* of the Society, because of his worthwhile contributions to our technical literature, because of his keen wit and great candor in discussion of our problems, because of his true scholarship, and because of his human interest in members and affairs of our Chapter.

The speaker of the evening, Victor M. Lathers, Rockford, Ill., gave an interesting talk on air distribution, which he very capably presented with the aid of slides, many of which recorded smoke tests on various types of air supply devices. An extended discussion followed, after which the meeting adjourned at 9:45 p.m.

WESTERN MICHIGAN HOLDS ANNUAL MEETING

May 26, 1942. The annual meeting of the Western Michigan Chapter was held at the Elk's Country Club, Kalamazoo, and the afternoon was devoted to golf, horseshoe pitching and target shooting.

The golf awards were made to K. Herman for low gross; the most four's to G. McCullough; most five's and Blind Bogey to T. Osberger; and most seven's to C. L. Mahoney. The Chapter cup was presented to V. H. Hill. Prof. C. H. Pesterfield was awarded for his skill in horseshoe pitching, S. H. Downs for his accuracy in target shooting, and Professor Reuling for his efforts in barn yard golf.

Dinner was served to 75 members and guests and following a report by the treasurer, Pres. W. G. Schlichting appointed tellers, who counted the ballots and reported the following officers elected for the 1942-43 season:

President—F. C. Warren
Vice-President—C. H. Pesterfield
Secretary—H. D. Bratt
Treasurer—V. H. Hill
Board of Governors—W. G. Schlichting, W. C. DeRoo, H. J. Metzger.

Mr. Downs then gave a report on the Society's Semi-Annual Meeting in St. Paul, and President Schlichting turned the meeting over to O. D. Marshall, who entertained the members and guests in his usual entertaining style. Mr. Hill led the group in singing many songs. Then Mr. Marshall and his committee *preferred charges* against all the retiring officers charging them with misconduct in the performance of their duties, while Mr. Downs acted as prosecuting attorney. The officers were represented by C. R. McConner and the Judge was John Dykman. Much to the amusement of the audience all the defendants were found guilty.

Short speeches were given by the newly elected president and vice-president, and then retiring President Schlichting thanked all the members for the hearty cooperation given him during his term of office and wished the incoming officers the same cooperation from the members. Prof. L. G. Miller presented Mr. Schlichting with the past president's plaque, and then the meeting adjourned.

FUEL FOR WAR EMERGENCY DISCUSSED AT CLEVELAND

May 11, 1942. The May meeting of the Northern Ohio Chapter was held at the Cleveland Engineering Society Club, Cleveland, and 38 members and guests were in attendance. Pres. J. A. Schurman, Jr., opened the meeting and called for the various committee reports which were submitted.

W. R. Beach then reported for the nominating committee, and a motion was made and passed that a unanimous ballot for the nominees be cast and the following are the newly elected officers:

President—C. M. H. Kaercher
Vice-President—Paul Gayman
Secretary—G. B. Priester
Treasurer—W. A. Evans
Board of Governors—J. A. Schurman, Jr., Philip Cohen, L. E. Slawson.

Mr. Kaercher then expressed his appreciation of the office to which he had been elected and outlined briefly his program for the coming year.

L. T. Avery then gave a short talk praising the Chapter officers who had served during the past year, and a rising vote of thanks was given.

The speaker of the evening, Tom Marsh, industrial engineer, was introduced and spoke on *Fuel for the War Emergency*, which he covered in detail. He stressed the importance of coal as a wartime necessity and urged the importance of buying coal for winter heating now, to provide an even load factor against production and transportation needs. He concluded his remarks by stating that it was vitally important that all fuel consumers place their plants in the best and most economical condition for efficient operation and ultimate fuel conservation.

Mr. Marsh's talk was well presented and received with the utmost interest. He introduced O. N. Fox, Associate Editor and local representative of the *Black Diamond Magazine*, who came as one of his guests. Mr. Fox talked for a short time on the subject of coal in the light of his knowledge, which he obtained through his work.

E. B. Denton, fuel engineer for the Louisville and Nashville Railroad, took the floor, and in a very forceful and interesting manner discussed the railroad shipment of coal and the difficulties with which this means of transportation was faced. Mr. Elstrom of the Norfolk and Western Railroad also added his comments on the transportation problems.

Mr. Diehl of the Smoke Abatement Department of the City of Cleveland, where he is a smoke inspector in charge of coal, made a brief speech in which he dramatically outlined the gravity of the situation and his suggestions for the proper handling of the problem. He suggested that representatives of all societies and other bodies interested in the consumption of fuel should form a special committee for the proper discussion of the problem and set up a means of handling it.

Mr. Moore of the Ohio Bituminous Coal Production Board also made a few remarks on this subject, followed by a lively discussion which was conducted by Mr. Marsh, who had been appointed honorary chairman. He carried out his task with considerable skill and diplomacy.

CAMOUFLAGE DISCUSSED AT NORTH TEXAS

June 8, 1942. The regular meeting of the North Texas Chapter was held at the Stoneleigh Hotel with 14 members and guests present at dinner. Pres. T. H. Anspacher called the meeting to order and the minutes of the previous meeting were read and approved.

Several committee chairmen submitted their reports for the year, and the program committee reported difficulty in securing speakers for future meetings and after some discussion, it was decided to make the July meeting a social affair.

The meeting was then turned over to H. C. Moore, architect from Houston, who discussed the art of camouflage as being practiced by the Axis and our Allies during the present emergency. Mr. Moore gave, in general, the history of camouflage, discussing the economic side of it and the four D's, dispersion, duplication, dummy and discipline, which are followed to a great extent at present in trying to conceal an object or fool the enemy.

A rising vote of thanks was extended Mr. Moore, after an interesting discussion.

SYNTHETIC RUBBER TOPIC AT SOUTHERN CALIFORNIA

May 6, 1942. The regular meeting of the Southern California Chapter was held at Eaton's Chicken House, Los Angeles, with 51 members and guests present. The meeting was called to order by Pres. A. J. Hess, who called for the introduction of guests and then proceeded with the business session.

A tabulation of the ballots for officers for the coming year was reported and the following were declared elected:

President—H. H. Bullock
Vice-President—W. O. Stewart
Secretary—Leo Hungerford
Treasurer—Maron Kennedy
Board of Governors—J. B. Griffith, A. J. Hess, P. C. Scofield, E. B. Wells.

The meeting was then turned over to Mr. Bullock, chairman of the program committee, who introduced Larry Reuland, B. F. Goodrich Rubber Co., who spoke on *Synthetic Rubber*. Mr. Reuland described a material known as Ameripol which to all intents and purposes is capable of replacing natural rubber. He explained that this product is manufactured entirely from petroleum, and then made an actual demonstration by mixing two properly processed liquids, which when mixed and stirred, coagulated into synthetic rubber. This substance was then rolled into a ball and when thrown onto the floor bounced to the ceiling. The audience showed great enthusiasm, thinking that the rubber problem had been solved. However, Mr. Reuland then informed his audience that it would be 1945 or 1946 before production of this item would be enough to supply the present demands.

The meeting was concluded by showing a sound motion picture film which illustrated the uses of synthetic rubber, which was both interesting and instructive.

PACIFIC NORTHWEST ANNOUNCES NEW OFFICERS

April 14, 1942. The regular monthly meeting of the Pacific Northwest Chapter was held at the

New Washington Hotel, Seattle, with 24 members and guests in attendance. Following dinner, members and guests were introduced and the secretary's report was read and accepted, followed by a report on the condition of the local chapter's finances by R. E. Chase.

A proposed wire was drafted to send to Pres. E. O. Eastwood, who was taken ill in Kansas City, while en route East, followed by a letter which was signed by those in attendance, and a unanimous standing vote of sympathy was extended and the secretary was instructed to make proper arrangements for appropriate flowers to be sent to President Eastwood.

A committee was appointed to act as tellers to count the ballots for the election of officers, and a unanimous vote for the following was announced:

President—H. T. Griffith
Vice-President—R. D. Morse
Secretary—R. E. LeRiche
Treasurer—G. E. Mead

F. J. Pratt made a few brief remarks, followed by B. Marcus Priteca, architect, who gave a very interesting talk covering the subject of what the architect expects of an engineer.

After an informal discussion the meeting adjourned.

WPB OFFICIAL ADDRESSES OKLAHOMA CHAPTER

April 14, 1942. The regular monthly meeting of the Oklahoma Chapter was held in the Library of the YMCA Building, and was called to order by Pres. A. R. Morin. The minutes of the previous meeting were read and approved, and President Morin appointed the following to serve on the nominating committee for the 1942-43 season: E. W. Gray, *chairman,* and Prof. E. F. Dawson.

J. Hobson Bass, Industrial Specialist of the War Production Board, was then introduced and spoke on *War Work and Industry.* Mr. Bass discussed the problems pertinent to conversion of industry to war work and the present trends in this locality. He also covered the operation of the Contract Distribution Branch of WPB and cited some very interesting and enlightening examples of transactions handled through the Oklahoma City office.

There were 16 members and guests present at this meeting which adjourned at 10:00 p.m.

JOHN J. BRAUN DIES OF HEART ATTACK

John J. Braun, vice-president and factory manager of the United States Playing Card Co., Cincinnati, and a member of the ASHVE for ten years, suffered a heart attack the day after his daughter, Miss Ruth Millicent Braun was married to F. G. Blackburn, Jr., Indianapolis,

John J. Braun

and died two days later in Christ Hospital, June 23, 1942.

Mr. Braun was born in Lebanon, N. J., November 3, 1887, the son of G. Frederick and Verana G. Braun, and received his early education in the public schools there, studying later at the Scranton, Pa., International Correspondence School and the Chicago American School of Correspondence. He also took several YMCA courses at night. He served as apprentice in engineering and drafting with the New Jersey Central Railroad from 1904-1908. For the next two years he served as a machinist and foreman in the Marine Division of the Central Railroad of Georgia, and in 1910 became engineer for The Ball and Wood Engine Co., Elizabethport, N. J., which position he held until 1914, when he became chief engineer, general superintendent and factory manager of the New York Consolidated Card Co., Long Island City, N. Y. He maintained this position until 1923 when he became assistant factory manager of the U. S. Playing Card Co., Cincinnati.

Mr. Braun was active in Masonry at Essex, N. Y., where he formerly resided, and in Cincinnati he held membership in the Scottish Rite and Shriners in addition to the Oola Khan Grotto, the *American Society of Mechanical Engineers,* the Engineers Club, *National Association of Power Engineers,* the *American Pulp and Paper Mill Superintendents Association,* the *International Association of Printing House Craftsmen,* Graphic Arts Research Bureau, *National Geographic Society* and was Trustee for the Presbyterian Church in Evanston, Cincinnati, and director of the Norwood Service League, Inc.

Mr. Braun served as Chairman of the Publicity Committee when the Society held its 39th Annual Meeting in Cincinnati in January 1933.

Mr. Braun is survived by his widow, Mrs. Amanda Braun; another daughter, Mrs. Eva V. Bonbright and a sister, Miss Ella A. Braun, to whom the Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere and heartfelt sympathy.

Funeral services were held at the Evanston Presbyterian Church on Thursday, June 25, at 2:00 p. m., and burial was in Rest Haven Memorial Cemetery.

CHARLES L. MEYER DIES AT 52

Charles L. Meyer, mechanical and sales engineer with the L. J. Wing Mfg. Co., New York, for the past 18 years, died suddenly on Friday, June 26, at his home 86-60 Palo Alto Avenue, Hollis, L. I.

Mr. Meyer was born in New York City on August 25, 1889, and after attending Manual Training High School and Pratt Institute, he spent three years at the Brooklyn Edison Co. as engineering assistant, which he held from 1908 to 1910. With Westinghouse, Church, Kerr & Co., he worked on power plant layouts, and in heating and ventilating. He was Fire Apparatus Test Engineer for the New York Central and Hudson Co., New York.

From 1915 to 1921 he was engaged in the development, design, and maintenance of manufacturing equipment, power plant and buildings, for National Aniline and Chemical Co., manufacturer of dyestuffs and chemicals. The following year he was sales engineer for

United Lead Co. on special and chemical equipment for steel and wire mills, coal mines, oil refineries and other industrial plants.

In 1922 he became associated with the Alexander Hamilton Institute, New York, handling sales and service in modern business course training for executives, and in 1924 he became sales engineer in charge of sales in the metropolitan district, New York State, Connecticut and New Jersey, for L. J. Wing Mfg. Co.

Besides being a member of the ASHVE, he was a member of the Engineers and Architects Square Club of New York, and a member of Sterling Lodge, F. & A. M.

Mr. Meyer is survived by his widow, mother, two brothers and two sisters to whom the Officers and Council of the Society extend their sincere sympathy. Masonic services were held on Sunday and burial was in Cypress Hills Cemetery, Brooklyn, on Monday, June 29.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 8 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by August 15, 1942, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
DUPUIS, JOSEPH E. R., Branch Mgr., Trane Company of Canada, Ltd., Montreal, Que., Canada (*Reinstatement*)	G. L. Wiggs	W. W. Timmins
FARBMAN, LEONARD, Engr., M. Farbman & Sons, Inc., New York, N. Y. (*Reinstatement*)	L. A. Hood	T. D. O'Connell
HOOPER, FREDERICK W., Vice-Pres., Ross Engineering of Canada, Ltd., Montreal, Que., Canada.	T. F. Rockwell	Milton Simkin
KOLAKOSKI, ROMAN, Owner, Clarendon Plumbing & Heating Co., Arlington, Va.	C. M Humphreys	J. C. Rose
KOLASA, MARION J., Engr., Gar Wood Industries, Detroit, Mich.	R. R. Noyes	Aylmer Hamlet
	C. W. Johnson	Leo Garneau
MOLER, WILLIAM H., Dist. Engr., Governair Corp., Dallas, Tex. (*Reinstatement*)	Andrew Jensen (*Non-member*)	Frank B. Campbell (*Non-member*)
SALTER, STANTON W., Heating Specialties, Engineering Equipment Co., Ltd., Montreal, Que., Canada.	Fred Jordan (*Non-member*)	Lester W. McCrea
TEMPLE, HAROLD L., Mech. & Elec. Engrg. Asst., (Heating, Ventilation & Air Cond. Div.) Air Ministry, London, England.	D. J. Luty	M. B. Shea
	W. G. Boales	W. H. Old
	L. C. McClanahan	R. G. Lyford
	Ross Zumwalt	T. H Anspacher
	A. B. Madden	Aylmer Hamlet
	A. M. Peart	Leo Garneau
	W. J. Moorcroft (*Non-member*)	A. S. Best (*Non-member*)
	J. K. Watson (*Non-member*)	C. M. Thompson(*Non-member*)

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ACHENBACH, PAUL R., Asst. Mech. Engr., National Bureau of Standards, Washington, D. C.

ANDREWS, WILLIAM R., Asst. Mgr., Ross Engineering of Canada, Ltd., Montreal, Que., Canada.

BAKER, THOMAS A., Vice-Pres., Baker Specialty & Supply Co., Logansport, Ind.

BLANCHARD, NORRIS M., Western Sales Mgr., L. J. Mueller Furnace Co., Omaha, Nebr.

BRYNER, JOHN J., Chief Engr., Roosevelt Hotel, New Orleans, La.

CLARKE, JOHN H., Marine Engr., U. S. Maritime Commission, Washington, D. C. (*Advancement*)

CUTTING, RICHARD H., Archt.-Engr., Garfield, Harris, Robinson & Schafer, Cleveland, O.

EDWARDS, CARVIS E., Design Engr., Consoer, Townsend and Quinlan and Battey and Childs, Parsons, Kans.

FINLAY, ALVIN E., Htg. Engr., Portland Gas & Coke Co., Portland, Ore.

HARRIS, WARREN S., Research Engr., University of Illinois, Urbana, Ill.

HUFF, JAMES M., Mgr., Mech. Dept., Robert & Co., Inc., Corpus Christi, Tex. (*Reinstatement*)

HUTCHINSON, FRANK W., Asst. Prof., University of California, Berkeley, Calif. (*Reinstatement*)

KIRKENDALL, HORTON J., Htg. Dept., A. H. Johnson Co., Pittsburgh, Pa. (*Advancement*)

LOCHMAN, EDWARD W., Owner, Edward W. Lochman Co., Kansas City, Mo.

MACFARLAN, NORRIS S., Sales Engr., Philadelphia Gas Works Co., Philadelphia, Pa.

MCFARLAN, ALDEN I., Sales Engr., Kerby Saunders, Inc., New York, N. Y.

PATTERSON, FRANK H., Sales & Service Engr., Hoffman Specialty Co., Indianapolis, Ind. (*Reinstatement*)

PEARSON, FRED L., Asst. Chief Mech. Engr., Giffels & Vallet, Inc., Detroit, Mich. (*Reinstatement*)

RILEY, JOHN N., Mgr., Danforth Co., Pittsburgh, Pa.

TRIEGEL, ERICH V., Mech. Engr., Francisco & Jacobus, New York, N. Y.

WEISS, EDWARD J., Asst. Industrial Air Cond. Engr., General Electric Co., Schenectady, N. Y.

WILLIAMSON, CHESTER C., Operator, H. J. Heinz Co., Pittsburgh, Pa.

ASSOCIATES

BORNSTEIN, ALFRED B., Partner, Wm. Bornstein & Son, Washington, D. C.

CLEMENT, EUGENE R., SR., Sales & Engrg., E. R. Clement, Inc., Bridgeport, Conn. (*Reinstatement*)

FAGAN, LAWRENCE E., Sales Engr., Chatham Malleable & Steel Products, Ltd., Toronto, Ont., Canada.

HOLDEN, ROBERT G., Mech. Engr., Holabird & Root, Marion, Ohio.

ROBERTS, EDWARD F., Partner, Edward F. Roberts Co., Philadelphia, Pa. (*Reinstatement*)

SCHULEIN, LARS E., Sales Engr., Economy Electric Manufacturing Co., Chicago, Ill.

SHELDON, ROBERT W., Sales Engr., The Lake Shore Gas Co., Ashtabula, O.

WIEDENMANN, WILLIAM A., Owner, W. C. Wiedenmann & Son, Kansas City, Mo.

JUNIORS

ALVAREZ, JOAQUIN, JR. Engr., Pittsburgh Lectrodryer Corp., Pittsburgh, Pa.

CLOW, SHERWOOD A., Sales Engr., Buffalo Forge Co., Dallas, Tex.

COHN, HENRY, Mech. Engr., Giffels & Vallet, Detroit, Mich.

FRIEDLIEB, MORTON J., Htg. & Vtg. Designer, Carribbean Archt.-Engr., New York, N. Y.

MORGAN, EDWIN H., JR., Draftsman, Chemical Construction Corp., New York, N. Y.

SCHAUER, ROBERT A., Htg. & Air Cond. Engr., Westinghouse Elec. & Mfg. Co., Canton, Ohio.

SOULE, JOHN P., Mech. Engr., Federal Shipbuilding & Dry Dock Co., Newark, N. J.

TUTT, RICHARD D., Air Cond. Engr., General Motors Corp. (Allison Div.), Indianapolis, Ind.

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